LEVEL I

ESL-TR-81-22

# TEST & EVALUATION OF COMMERCIALLY AVAILABLE HALON 1211 HAND-PORTABLE FIRE EXTINGUISHERS FOR USE IN HABITABLE & CARGO COMPARTMENTS OF USAF AIRCRAFT

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This report describes the results of a test and evaluation program of commercially available, off-the-shelf Halon 1211 hand-portable fire extinguishers. The primary emphasis of the test program was aimed at establishing the flight-worthiness/crashworthiness characteristics of candidate articles. Tests were also conducted to evaluate the test item's design features, function, operational capabilities and maintainability. Results of this test program will be used in establishing procurement specifications for Halon 1211 first-aid hand-portable fire extinguishers for use on board USAF aircraft.

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## PREFACE

This report was prepared by the Air Force Engineering and Services Center, Engineering and Services Laboratory at Tyndall AFB, Florida, under Job Order Number 2505-1013, Halon Pressurized Fire Extinguishers for Aircraft. The efforts were sponsored by the Air Force Systems Command (AFSC/SDNE), Andrews AFB, Maryland.

This report documents the environmental testing and evaluation of selected commercial, off-the-shelf Halon 1211 hand-portable fire extinguishers. The report does not constitute an endorsement or rejection of these products by the Air Force, nor can it be used for advertising a product.

This report has been reviewed by the Public Affairs officer (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public including foreign nationals.

This technical report has been reviewed and is approved for publication.

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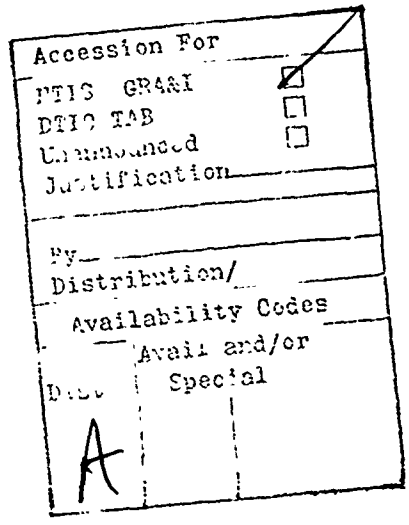




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TABLE OF CONTENTS

TABLE OF CONTENTS (Concluded)

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Concluded)

LIST OF TABLES

# SECTION I

# INTRODUCTION

## 1. OBJECTIVE

The objective of this test program was to identify commercially available, off-the-shelf, Halon 1211 hand-portable fire extinguishers that would meet established specifications for use in habitable and cargo compartments of military aircraft.

## 2. BACKGROUND

### a. Existing Capability

The standard extinguisher in use throughout the Air Force is the A-20 container filled with Halon 1011 (chlorobromomethane - CB). Several hundred thousand of the A-20 portable fire extinguishers have been placed in service since its adoption as an Air Force standard item in December 1949. Over the past 31 years of world-wide use, some problems have been reported as would be expected. However, most of these problems with the one-quart A-20 extinguisher have centered around the toxicity of the agent Halon 1011. The overall program to provide a more effective and less toxic, all-purpose extinguisher for Air Force aircraft came as a result of a Strategic Air Command Required Operating Capability (SAC-ROC), issued in September 1968, which was endorsed by the other major commands (Reference 1).

### b. Identification of a Replacement Agent for Halon 1011 (CB)

(1) The search for a suitable agent to replace Halon 1011 focused upon the following capabilities specified by SAC-ROC 12-68:

(a) The extinguishing agent should not present a significant toxic hazard either directly, or through its pyrolysis products, when used in the confined crew station or cargo areas of military aircraft.

(b) The replacement agent should permit multipurpose application to better combat aircraft cabin fires encompassing solid materials (Class A), flammable liquids (Class B), and electrical equipment (Class C).

(c) The extinguishing agent should be contained in a unit that is sufficiently portable so as to be transported and operated by a crew member without excessive efforts.

(2) At the inception of the program to identify a replacement agent for Halon 1011 (CB), the desired agent characteristics were defined further in a joint statement by the Air Force Aero Propulsion Laboratory (AFAPL) and the Aeronautical Systems Division. The replacement agent should be:

(a) less toxic than Halon 1011 in undegraded form;

(b) equal to or better than Halon 1011 in extinguishing Class "A" fires;

(c) equal to or better than Halon 1011 in extinguishing Class "B" fires;

(d) suitable for use on Class "C" fires;

(e) capable of extinguishing all classes of fire from a minimum distance of 10 feet;

(f) usable and effective over the range of -60°F to +160°F;

(g) less corrosive to aircraft structural materials than Halon 1011.

During the technical programs conducted jointly by AFAPL and ASD, the following agent materials were evaluated, using Halon 1011 as the basis for comparison:

Halon 1211 - Bromochlorodifluoromethane ($CBrClF_2$)

Halon 1301 - Bromotrifluoromethane ($CBrF_3$)

Halon Foam - a compound agent (developed under USAF contract by Arthur D. Little, Inc.)

The development effort was detailed in Technical Reports AFAPL-TR-71-21 and AFAPL-TR-72-62 (References 2 and 3).

(3) In the chronology of developmental programs, an AFAPL-sponsored study conducted by the Federal Aviation Administration (FAA/NAFEC) can be seen as the logical predecessor of the test program that is the subject of this report.

The study (AFAPL-TR-79-2036, Reference 4), as a result of an extensive, four-phase test program, recommended Halon 1211 over Halon 1301 or Halon Foam as a replacement for Halon 1011 in hand-portable fire extinguisher units.

At a July 1978 meeting, co-sponsored by AFAPL/SFH and ASD/ENFEF, and attended by representatives of the major USAF operating commands, the US Army and the US Coast Guard, the position was established that Halon 1211 was the most acceptable alternate to Halon 1011, should Halon 1011 become unavailable for use (Reference 5).

As a culmination of the aforementioned efforts, Halon 1211 was identified as a standard extinguishing agent (MIL-B-83741) and recommended for USAF use. However, the existing specification extinguisher container, the A-20, proved ineffective when filled with Halon 1211.

Recognizing the urgency to obtain a suitable first aid Halon 1211 extinguisher, and aware of the impending prohibition of Halon 1011 by the

Occupational Safety and Health Administration (OSHA), the Air Force Inspection and Safety Center, on 24 June 1980, issued a Statement of Need (SON) listing desired characteristics for a new aircraft extinguisher (Reference 6).

(4) The test and evaluation of commercially available, off-the-shelf Halon 1211 hand-held fire extinguishers, a task assigned to the Air Force Engineering and Services Center by Air Force Systems Command (AFS/SDNE) commenced on 4 August 1980.

(5) Effective 11 December 1980, OSHA prohibited the use of the Chlorobromomethane (CB) agent in fire extinguishers.

3. METHOD OF APPROACH

a. Scope of the Test Program

The program encompassed test and evaluation of state-of-the-art, commercially available Halon 1211 hand-portable fire extinguishers of the following Underwriters' Laboratory (UL) classification and agent content:

| UL Classification and Rating | Minimum Quantity of Halon 1211 Agent |
|---|---|
| 10B:C | 5 lb |
| 1A:10B:C | 9 lb |
| 2A:40B:C | 14 lb |
| 2A:60B:C/3A:80B:C | 17 lb |

Extinguishers selected for inclusion in the test sample were those which had obtained UL listing status as of 1 July 1980 for the types of extinguishers shown above.

b. Size of Test Sample

Five extinguishers of each of the aforementioned sizes from the following manufacturers constituted the test sample (Manufacturers' data detailed in Appendix A):

(1) Amerex Corporation

(2) Ansul Company

(3) Graviner, Inc.

(4) Potter-Roemer Co.

(5) Pemall Co.

(6) Protectoseal Company

Since the mounting bracket was considered to be the critical item in the extinguisher/agent/bracket combination in several of the planned tests, commercially available "heavy duty aircraft/vehicular" mounting brackets were included in the test sample.

c. Assumptions

(1) UL listing of a manufacturer's product, as denoted by appropriate markings on the extinguisher's label, was taken as evidence that the item had met the requirements established by Underwriters Laboratory for Halon 1211 hand-held fire extinguishers (References 7 and 8). No verification of those UL-specified attributes was deemed necessary.

(2) When it was known that the extinguishers would be likely to encounter conditions more severe or less severe than the environmental levels stated in MIL-STD-810C (Reference 9), or other applicable specifications, the test could be modified to reflect those known conditions.

## SECTION II

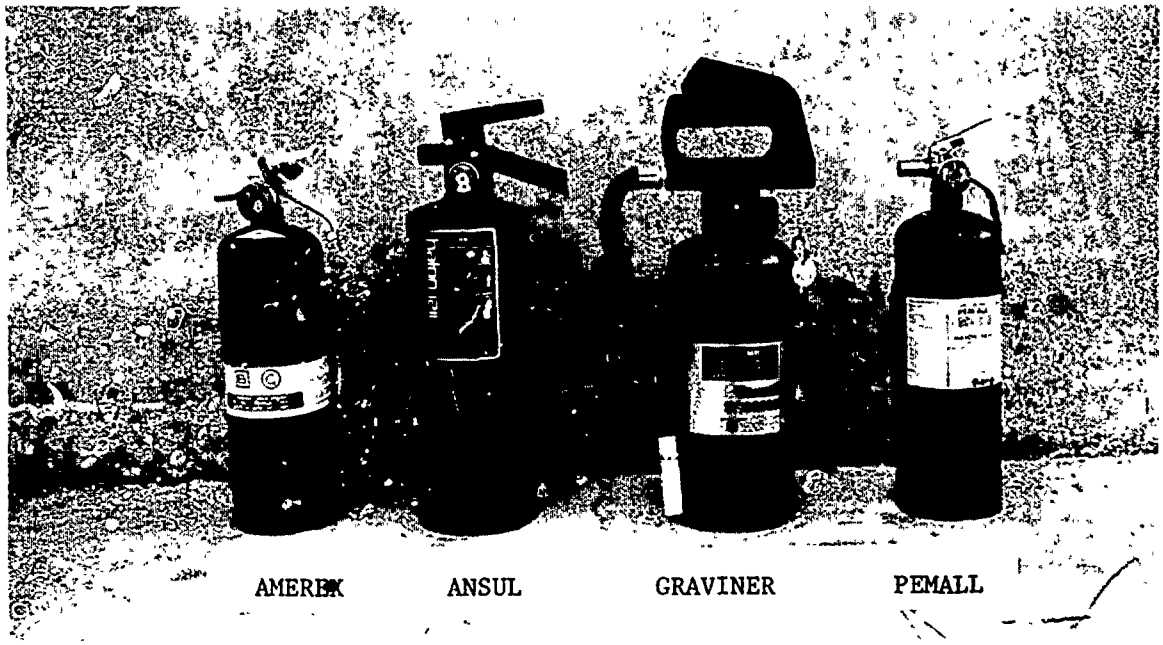
## DESCRIPTION OF TEST ARTICLES

### 1. INTRODUCTION

a. The purpose of this section is to introduce and describe those Halon 1211 fire extinguishers and associated brackets evaluated during the test program. The following figures and tables show the range of test samples and provide sufficient identifying data to allow the reader to obtain meaningful information from subsequent sections of this report which describe the various test objectives, procedures and results.

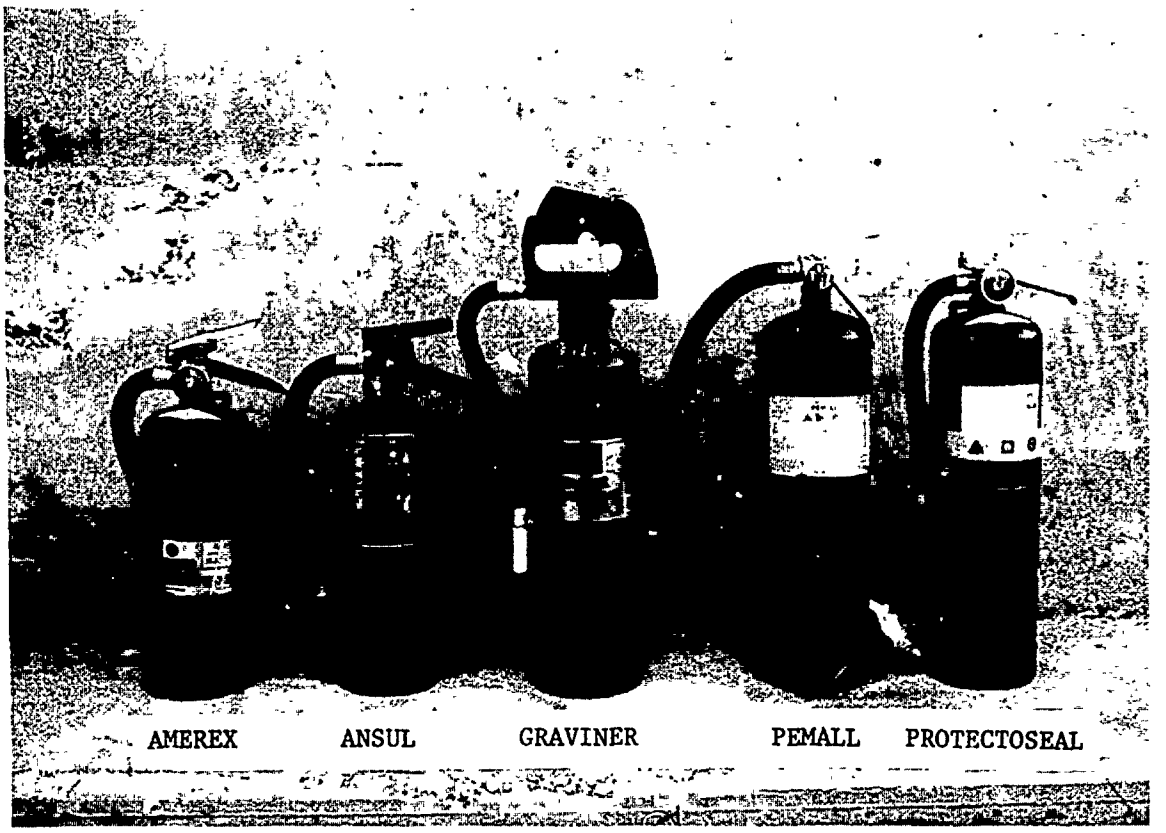
### 2. EXTINGUISHER DATA

a. Figures 1, 2, and 3 show test extinguishers categorized by Manufacturer and Underwriters Laboratory (UL) ratings.



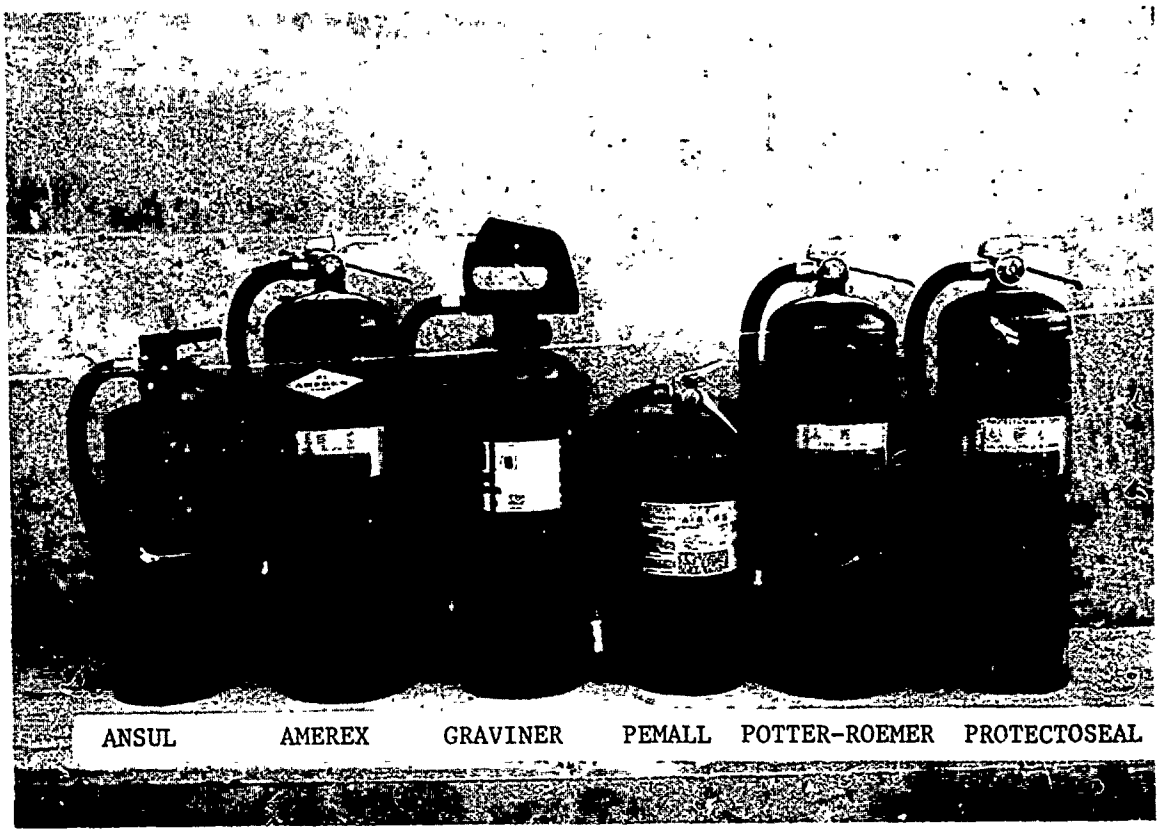

| UL RATINGS/MANUFACTURER/MODEL NO. | | | GROSS WEIGHT (lb) | GROSS WEIGHT (oz) | NOMINAL AGENT WEIGHT (lb) | NOMINAL AGENT WEIGHT (oz) | DIMENSIONS HEIGHT x DIAMETER (inches) | MAXIMUM OPERATING PRESSURE (PSIG) |
|---|---|---|---|---|---|---|---|---|
| 10B:C | Amerex | (355) | 8 | 2 | 5 | 0 | 15-5/8 x 4-1/4 | 125 |
| 10B:C | Ansul | (SY-0541) | 10 | 6 | 5 | 0 | 16-1/2 x 4-7/8 | 100 |
| 10B:C | Graviner | (7-10) | 14 | 0 | 7 | 0 | 18-1/4 x 5 | 125 |
| 10B:C | Pemall | (PA-H5.5) | 8 | 14 | 5 | 8 | 15-1/4 x 4-1/4 | 125 |

Figure 1. 10B:C Rated Fire Extinguishers




| UL RATINGS/MANUFACTURER/MODEL NO. | | | GROSS WEIGHT (lb) | GROSS WEIGHT (oz) | NOMINAL AGENT WEIGHT (lb) | NOMINAL AGENT WEIGHT (oz) | DIMENSIONS HEIGHT x DIAMETER (inches) | MAXIMUM OPERATING PRESSURE (PSIG) |
|---|---|---|---|---|---|---|---|---|
| 1A:10B:C | Amerex | (369) | 14 | 8 | 9 | 0 | 17 x 5-3/8 | 195 |
| 1A:10B:C | Ansul | (SY-094J) | 14 | 7 | 9 | 0 | 16-1/2 x 4-7/8 | 125 |
| 1A:10B:C | Graviner | (9-12) | 17 | 8 | 9 | 0 | 22 x 5 | 125 |
| 1A:10B:C | Pemall | (PA-H10) | 15 | 5 | 10 | 0 | 20 x 5 | 125 |
| 1A:10B:C | Protectoseal | (370) | 15 | 12 | 9 | 0 | 20 x 5 | 195 |

Figure 2. 1A:10B:C Rated Fire Extinguishers




| UL RATINGS/MANUFACTURER/MODEL NO. | | | GROSS WEIGHT (lb oz) | | NOMINAL AGENT WEIGHT (lb oz) | | DIMENSIONS HEIGHT x DIAMETER (inches) | MAXIMUM OPERATING PRESSURE (PSIG) |
|---|---|---|---|---|---|---|---|---|
| 3A:80B:C | Amerex | (361) | 35 | 13 | 17 | 0 | 24 x 7 | 195 |
| 2A:40B:C | Ansul | (SY-1441) | 22 | 0 | 14 | 0 | 19 x 5-5/8 | 150 |
| 2A:20B:C | Graviner | (16-14) | 32 | 4 | 16 | 0 | 23-1/4 x 6-5/8 | 175 |
| 2A:40B:C | Pemall | (PA-H14) | 21 | 12 | 14 | 0 | 17 x 6 | 195 |
| 2A:60B:C | Potter-Roemer | (361) | 35 | 13 | 17 | 0 | 24 x 7 | 195 |
| 2A:60B:C | Protectoseal | (361) | 35 | 13 | 17 | 0 | 24 x 7 | 195 |

Figure 3. 3A:80B:C, 2A:40B:C, 2A:20B:C and 2A:60B:C Rated Fire Extinguishers

b. Figures 4 through 9 depict the range of test samples of each manufacturer which underwent the test and evaluation program.

Figure 4. Amerex Test Items

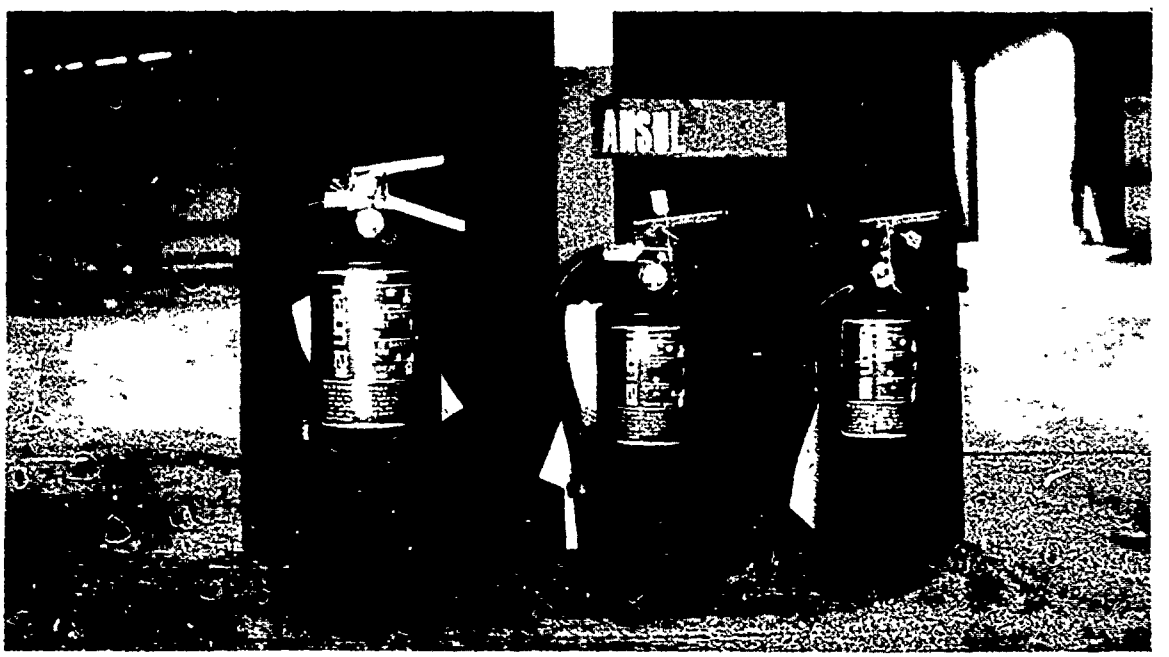



Figure 5. Ansul Test Items

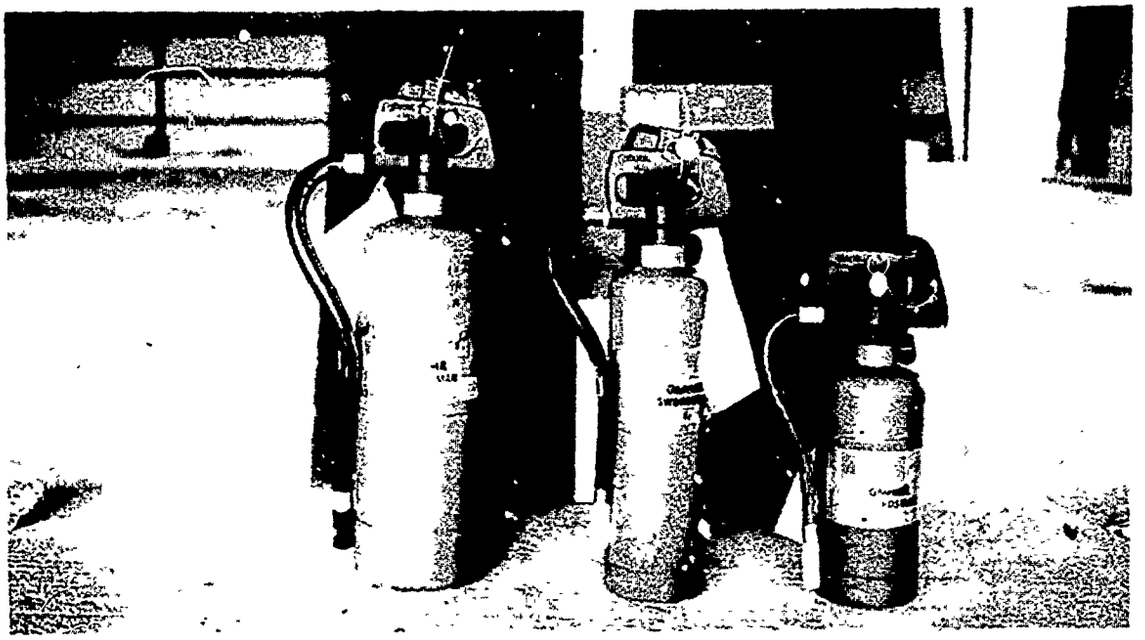


Figure 6. Graviner Test Items

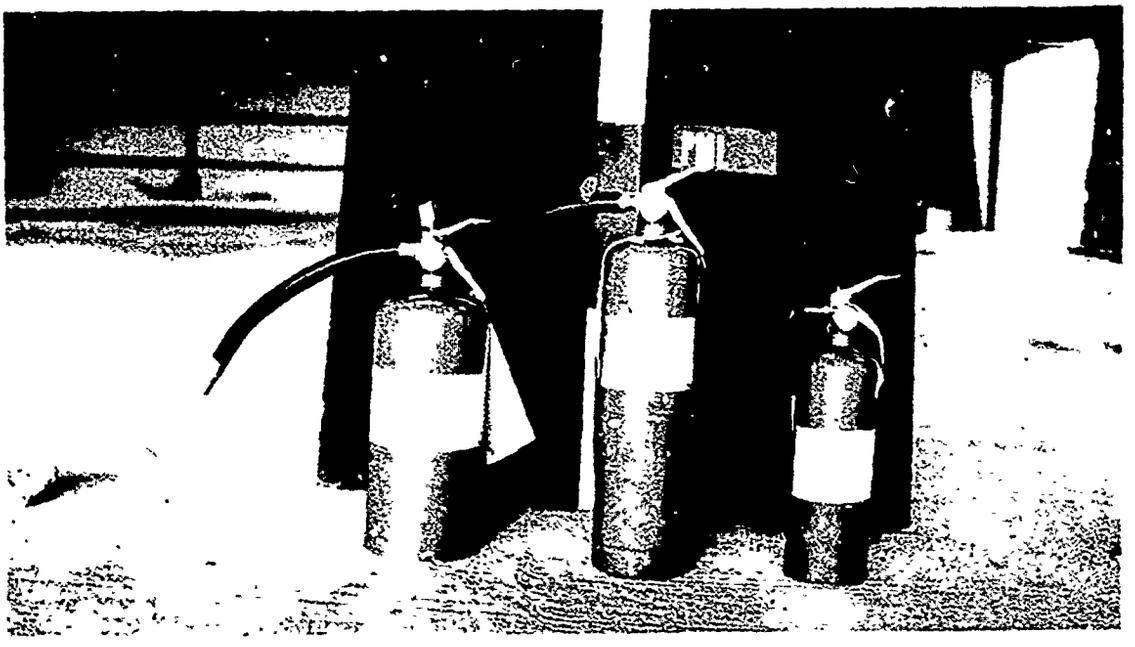


Figure 7. Pemall Test Items

Figure 8. Potter-Roemer Test Item

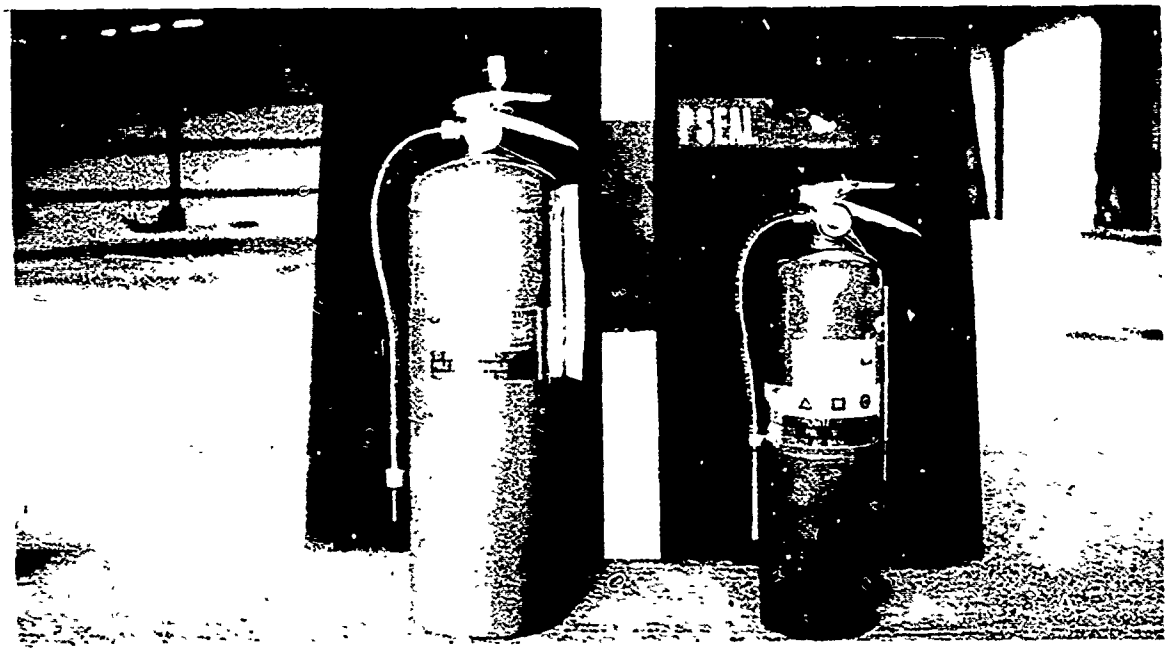
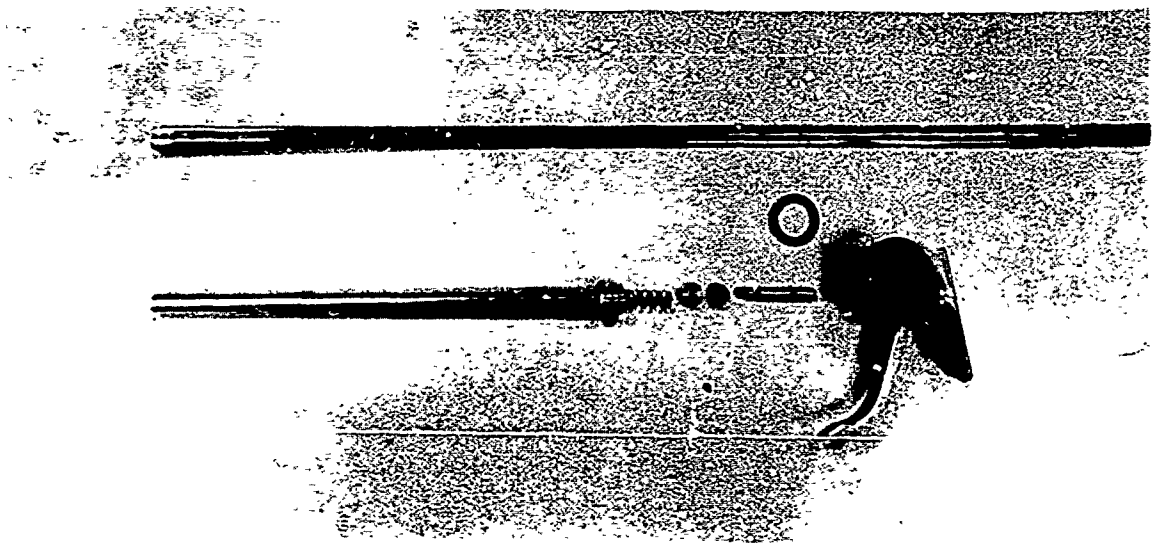


Figure 9. Protectoseal Test Items

## 3. EXTINGUISHER MATERIALS AND CONSTRUCTION

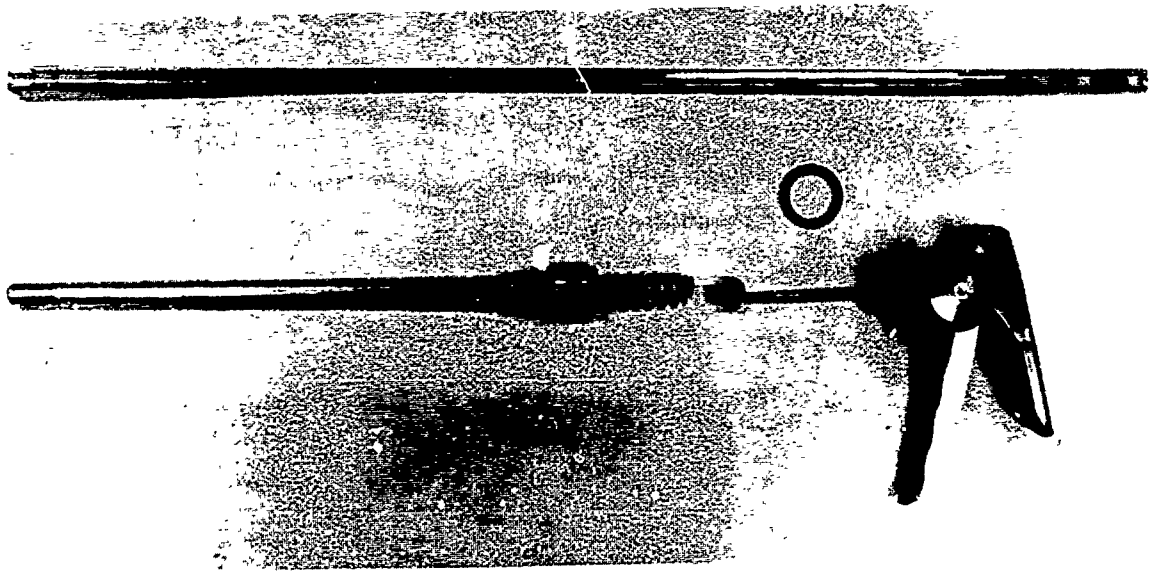
Depicted below in Figures 10 through 14 are materials and construction and physical descriptions of test item components categorized by manufacturer and UL rating.



MATERIALS AND CONSTRUCTION

| | Extinguisher Body | Static Seal | Dip Tube | Valve Head | Discharge Nozzle | Washers & Seals |
|---|---|---|---|---|---|---|
| Amerex (10B:C) | Steel: Seamless sides, seam at bottom. | Aluminum shaft, rubber seal, (seal removable). | Aluminum | Polished aluminum valve body, aluminum handles. | Aluminum | O-Rings at nozzle/ valve connection and at valve/cylinder connection on valve shaft. |

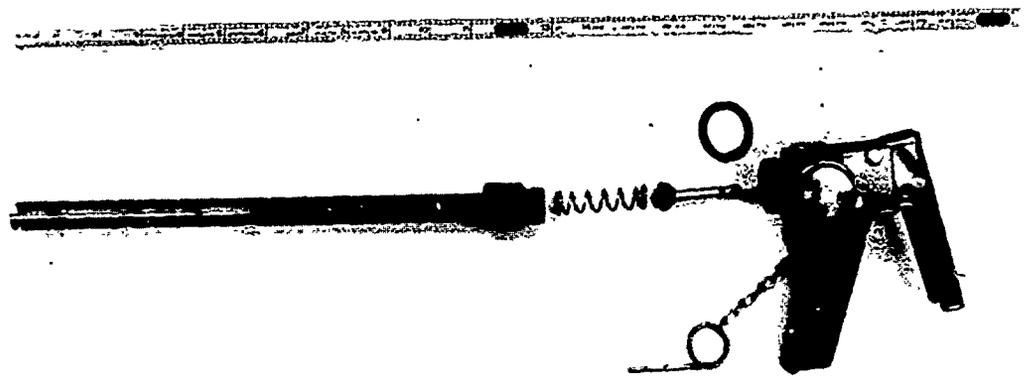
Figure 10. Amerex 10B:C Components



MATERIALS AND CONSTRUCTION

| | Extinguisher Body | Static Seal | Dip Tube | Valve Head | Discharge Nozzle | Washers & Seals |
|---|---|---|---|---|---|---|
| Amerex (1A:10B:C) Potter-Roemer (2A:60B:C) Protectoseal (2A:60B:C) | Steel: Seamless sides, bottom seam. | Stainless steel shaft, brass and rubber seal (removable). | Aluminum | Chrome plated brass valve head. Handles: chromed steel. | Rubber hose with brass fittings, plastic nozzle. | O-Rings on valve shaft, valve/neck connection. Flat rubber (neoprene E) washer at hose/valve connection. |
| Protectoseal (1A:10B:C) | Steel: One mid-seam, bottom seamless with cap. | As above. | As above. | As above. | As above. | As above. |
| Amerex (3A:80B:C) | Steel: Welded seams at top, bottom and down side, neck-seam. | As above. | As above. | As above. | As above. | As above. |

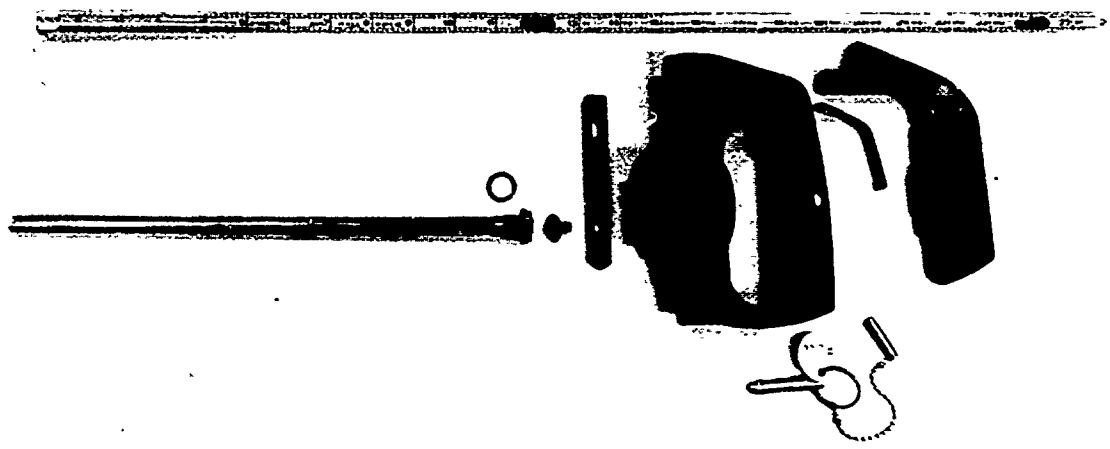
Figure 11. Amerex 1A:10B:C and 3A:80B:C; Potter-Roemer 2A:60B:C; and Protectoseal 1A:10B:C and 2A:60B:C Components



MATERIALS AND CONSTRUCTION

| | Extinguisher Body | Static Seal | Dip Tube | Valve Head | Discharge Nozzle | Washers & Seals |
|---|---|---|---|---|---|---|
| Ansul (10B:C) | Steel: Seamless sides, seam at bottom, neck-welded seam. | Steel shaft, rubber seal, (single unit). | Steel | Anodized aluminum valve body, painted steel handles. | Anodized aluminum | O-Rings, on valve shaft, neck/valve connection (special). |
| Ansul (1A:10B:C) (2A:40B:C) | As above. | As above. | As above. | As above. | Rubber hose with aluminum fittings, plastic nozzle. | As above. |

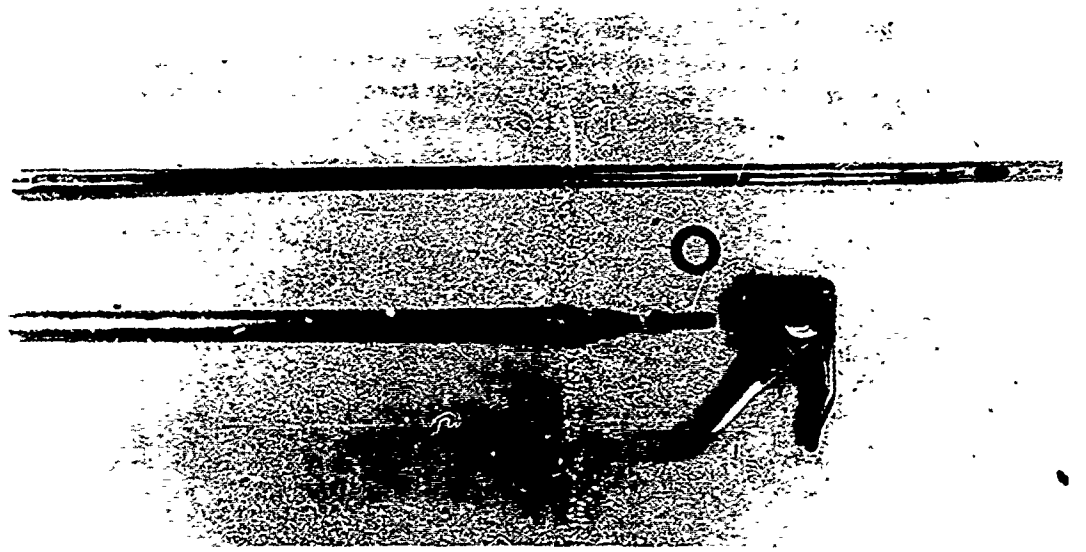
Figure 12. Ansul 10B:C, 1A:10B:C and 2A:40B:C Components



MATERIALS AND CONSTRUCTION

| | Extinguisher Body | Static Seal | Dip Tube | Valve Head | Discharge Nozzle | Washers & Seals |
|---|---|---|---|---|---|---|
| Graviner (10B:C) (1A:10B:C) (2A:20B:C) | Steel: One mid-seam in side wall, bottom seamless w/cap. | Dip tube end fitted with breakaway brass seal (cap). | Brass | Handles and valve body, anodized aluminum. | Rubber hose with aluminum fittings and plastic nozzle. | O-Rings, secondary seal, valve/neck connections, brass washer at dip tube/cylinder connection. |

Figure 13. Graviner 10B:C, 1A:10B:C and 2A:20B:C Components



MATERIALS AND CONSTRUCTION

| | Extinguisher Body | Static Seal | Dip Tube | Valve Head | Discharge Nozzle | Washers & Seals |
|---|---|---|---|---|---|---|
| Pemall (10B:C) | Steel: Seamless sides, bottom seam. | Brass shaft, rubber seal, (single unit). | Aluminum | Chrome plated brass with aluminum handles. | Brass (chrome plated). | O-Rings, valve shaft, valve/neck connection. |
| Pemall (1A:10B:C) (2A:40B:C) | Steel: One mid-seam, bottom seam-less with cap. | As above. | As above. | As above. | Rubber hose with aluminum and brass fittings, nozzle is aluminum. | As above. |

Figure 14. Pemall 10B:C, 1A:10B:C and 2A:40B:C Components

4. MOUNTING BRACKET DATA

a. The following figures and associated paragraphs describe the heavy duty vehicle or aircraft type brackets used during the test and evaluation phase. Brackets are categorized by manufacturer and model number and the narrative addresses materials and construction.

(1) AMEREX BRACKETS (Figures 15 and 16)

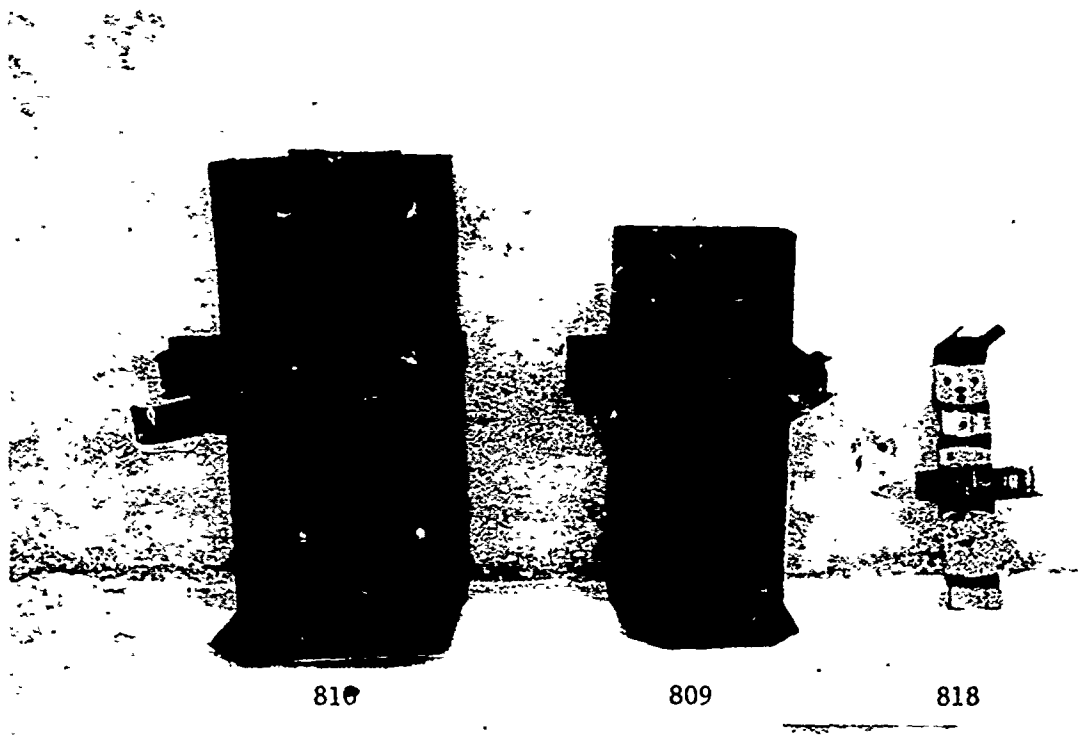



Figure 15. Large, Medium and Small Amerex Brackets

(a) 810 - This is a large bracket designed for 2A:60B:C Halon 1211 (16- to 17-pound) extinguishers. The 810 is equipped with two stand-off braces, which hold the extinguishers off of the mounting surface, and an adjustable strap that will accommodate several diameters of extinguishers within this size range. Construction materials consist of painted steel (Figure 15).

(b) 809 - The 809 Bracket design follows the 810 Model. It is dimensioned smaller to accommodate Halon 1211 extinguishers in the 1A:10B:C (9- to 10-pound) range. Being adjustable, the 809 Bracket will accommodate several diameters of extinguishers within this size range (Figure 15).

(c) 818 - This bracket is specifically designed for the Amerex Model 355 10B:C (5-pound) Halon 1211 extinguisher. The 818 has a neck yoke, dimensioned to fit grooves in the neck portion of the extinguisher's valve assembly. There is also a single nonadjustable strap with a cam-type lock to secure the extinguisher. Construction materials consist of painted steel (Figure 15).

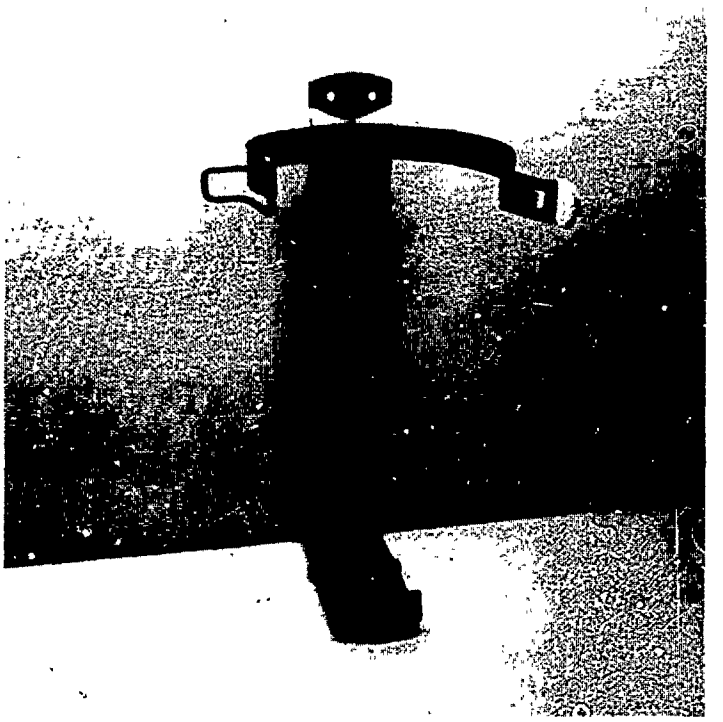


Figure 16. Heavy Duty Amerex Small Extinguisher Bracket

(d) 821 - This is a "heavy duty" bracket designed for the Model 355 10B:C (5-pound) Amerex Halon 1211 extinguisher. This is a full length bracket, without the neck yoke. Instead, there is a fixed base retainer. As with the 818, the 821 has a single nonadjustable strap with a cam lock buckle. The entire bracket consists of painted steel (Figure 16).

(2) PEMALL BRACKETS (Figure 17)

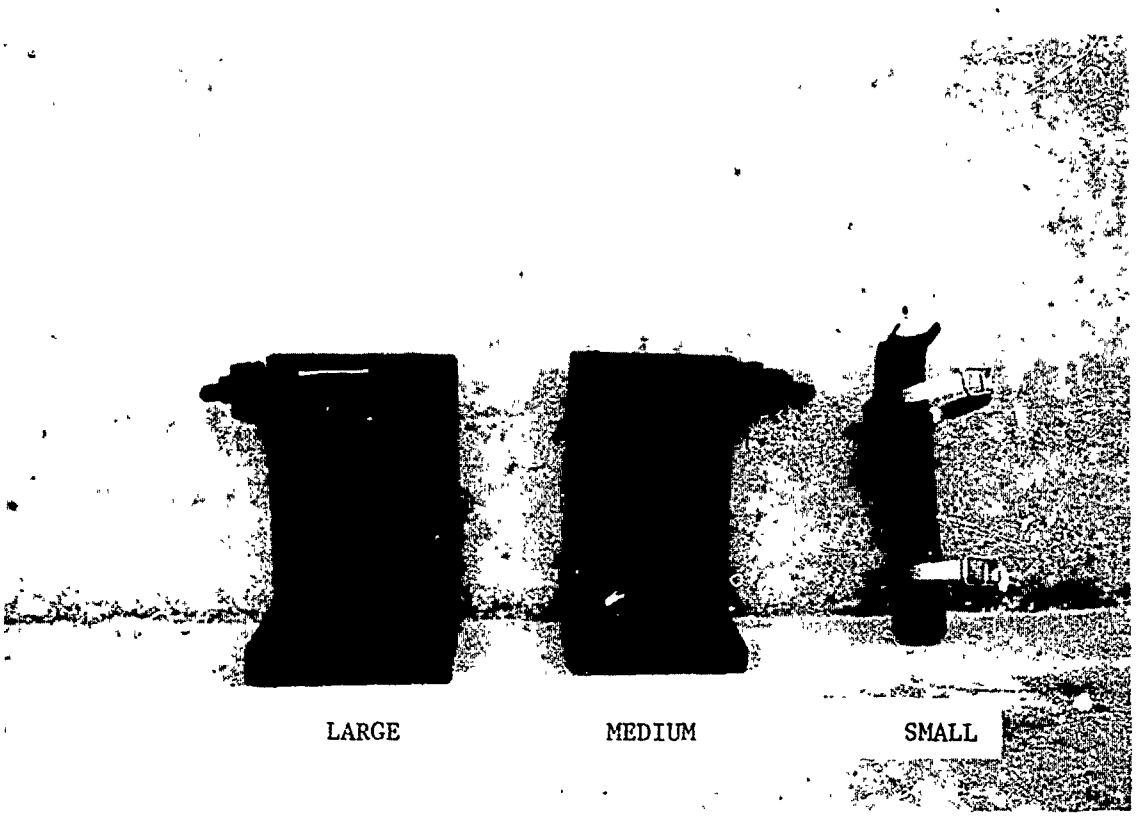



Figure 17. Large, Medium and Small Pemall Brackets

(a) Large Pemall - This bracket is dcsigned for the Pemall 14-pound Halon 1211 extinguisher (Model PA-14, 2A:40B:C). The bracket has a base plate and a single, nonadjustable strap with a cam lock buckle. Construction materials consist of painted steel (Figure 17).

(b) Medium Pemall - This bracket is designed for the Pemall 10-pound Halon 1211 extinguisher (Model PA-10, 1A:10B:C). Design characteristics and construction materials are identical to the Large Pemall Bracket (Figure 17).

(c) Small Pemall - The Small Pemall Bracket is designed to accommodate the Pemall 5.5-pound Halon 1211 extinguisher (Model PA-H5.5, 10B:C). It is similar to the Amerex 818. It has a neck yoke and two nonadjustable straps. These straps are made of stainless steel and are equipped with stainless steel cam lock buckles. The back brace is painted steel (Figure 17).

## SECTION III

## TEST CRITERIA

### 1. GENERAL CONSIDERATIONS

#### a. Test Criteria

Criteria used in the conduct of this test and evaluation program were derived from:

(1) Proposed Purchase Description for Extinguisher, Fire, Bromochlorodifluoromethane, Portable (Halon 1211), WR-ALC/IRA 4210-031, dated 16 April 1979 (Reference 10).

(2) Draft Design Features, Enclosure 2 to AF/SC, 1-80, Statement of Operatinal Need (SON) for Aircraft Handheld Fire Extinguisher (Halon 1211), dated 24 June 1980 (Reference 6).

#### b. Rationale

(1) Conflicting Criteria

When criteria established by References 6 and 10 above, were found to be in conflict (e.g., burst pressure of 400 psig versus 1000 psig), the more stringent requirement was used for the test design.

(2) UL Listing Status

As previously stated, listing status by the Underwriters' Laboratory was taken as evidence that the candidate extinguisher had met the requirements of UL Standard 711 and 1093 (References 7 and 8), and no additional testing to verify those standards was undertaken.

(3) NFPA Standard

The range of each extinguisher's horizontal discharge stream was established and the average time of discharge was recorded to obtain baseline data for evaluation of post-exposure performance; however, no attempt was made to verify the Halon 1211 agent's effectiveness in combating actual fires. Table A-2-1, Characteristics of Extinguishers, National Fire Codes 1980, Volume I, National Fire Protection Assn. (Reference 11), served as the reference for rating extinguisher performance with respect to throw distance and discharge times.

### 2. SCORING TECHNIQUE

#### a. Methodology

The results obtained in each subtest were independently evaluated by members of the project team using evaluation sheets shown in Appendix B. For

each subtest, test articles were evaluated for their ability to satisfy the various test criteria with a score of 10 being the highest value obtainable and 0 being the lowest. Each subtest was rated for its importance to the overall test program and given a Weighting Index (WI). A WI of 10 indicated a critical consideration, and a WI of 3 is of much less importance to the extinguisher's performance. The total value for each subtest was obtained by multiplying the score by the Weighting Index. An example of the scoring technique used is given below.

Example:

Subtest - Ballistic Penetration

Criterion - The extinguisher shali be capable of withstanding the impact of a caliber .50 armor piercing projectile without shattering or fragmentation of the body.

| | | | |
|---|---|---|---|
| Body intact. Projectile entry and exit hole only. | Slight deformation. No spalling. | Major deformation. No spalling. | Fragmented, shattered body. |
| 10 | 7 | 4 | 0 |

WEIGHTING INDEX: 10

b. Ranking of Test Articles

The total value for each subtest was summed, and an average of the evaluations was tabulated to obtain an informal ranking of the test articles by size and manufacturer.

## SECTION IV

## TEST RESULTS

### 1. ORGANIZATION OF DATA

a. General

This section describes the results of testing and evaluation conducted during the period August through October 1980. While this final report is complete within itself with respect to the stated objectives of the test effort, the reader is encouraged to review the literature pertaining to halogenated agents used in first aid, hand-held fire extinguishers (References 12 through 20).

b. Test and Evaluation Program

"Test" used in the context of this program denoted the acquisition of data derived from the physical exercise of the extinguisher. "Evaluation" was seen as the process whereby data from any and all pertinent sources were logically assembled and analyzed to provide a basis for authoritative assessments. It follows from this distinction that there were two separate, though related, processes involved: that for the physical testing and that for evaluation. In some cases, due to the short lead time available for completing the program, these processes occurred at nearly the same point in time and may be difficult to distinguish. Nevertheless, great care was taken to state clearly whether test, evaluation, or both processes served as the basis for establishing the test article's performance rating.

### 2. TEST RESULTS

a. Flightworthiness/Crashworthiness Test and Evaluation

The series of tests described below were designed to determine the test articles' resistance to the effects of natural and induced environmental conditions peculiar to military aircraft. With minor modifications, the test sequence followed the recommended chronology outlined in Table 1 of MIL-STD-810C (Reference 9).

(1) Leakage

(a) Objective

The objective of this test was to evaluate extinguishers for leakage both prior to initiation of the test sequence and before and after each subtest.

(b) Procedure

Randomly selected extinguishers of each representative size and manufacturer were weighed and recorded to the nearest gram using a Mettler

P515 balance. The extinguishers were placed in storage at a constant temperature of 70°F along with a steel bar of known mass which was employed as a control to test variation of the Mettler balance. At the end of 7 days, the extinguishers and control bar were reweighed and data recorded. Leakage rates were then calculated from this data. Extinguisher leakage was also tested and recorded prior to and immediately following all subtests, using a General Electric Tracker® II Freon Leak Detector having a detection sensitivity of 0.5 oz/year.

(c) Results

No leakage was detected using the weighing method. Agent leakage detected during subsequent tests was by means of the GE Tracker® II Freon Leak Detector.

(2) Method of Operation and Extinguisher Recharging

(a) Objective

The objective of this test was to determine the ease of operation, mechanical durability, and discharge characteristics (distance and pattern) of each extinguisher in the test sample.

(b) Procedure

A locally fabricated device was used to hold and discharge the extinguishers to ensure reproducible conditions in this phase of testing. This device consisted of a metal frame with a shaft equipped with a cam which allowed exact pressure to be applied on each discharge and a variable holding bracket which allowed accommodation of all sizes of extinguishers to be tested (Figure 18).

Extinguishers were placed in the holding bracket and adjustments made to accommodate extinguisher size. A torque wrench was attached to the end of the shaft to measure the inch-pounds required for the cam to discharge the extinguisher.

Signs numbered in increments of 5 feet were placed at 5-foot intervals along a straight line and anchored to the ground. A 4- x 4-foot backboard with vertical color divided marking stripes, divided into 1-foot increments, was placed between the 10- and 15-foot markers to measure the vertical height of the extinguisher discharge stream.

The initial discharge served to establish baseline data. The test extinguisher, factory-charged with Halon 1211, was discharged horizontally across the numbered baseline to determine the throw distance; (Figure 19) vertical range of discharge was measured on the backboard. After this initial discharge of the Halon charge, the extinguishers were repressurized with nitrogen, and the recharge-discharge sequence was repeated 23 times. Evaluation of variations in inner seal spring tension and seal wear was thus achieved at minimum cost. The extinguishers were then refilled with Halon 1211 and pressurized with nitrogen according to manufacturers' specifications. The test sequence used in the initial discharge was then repeated with the Halon

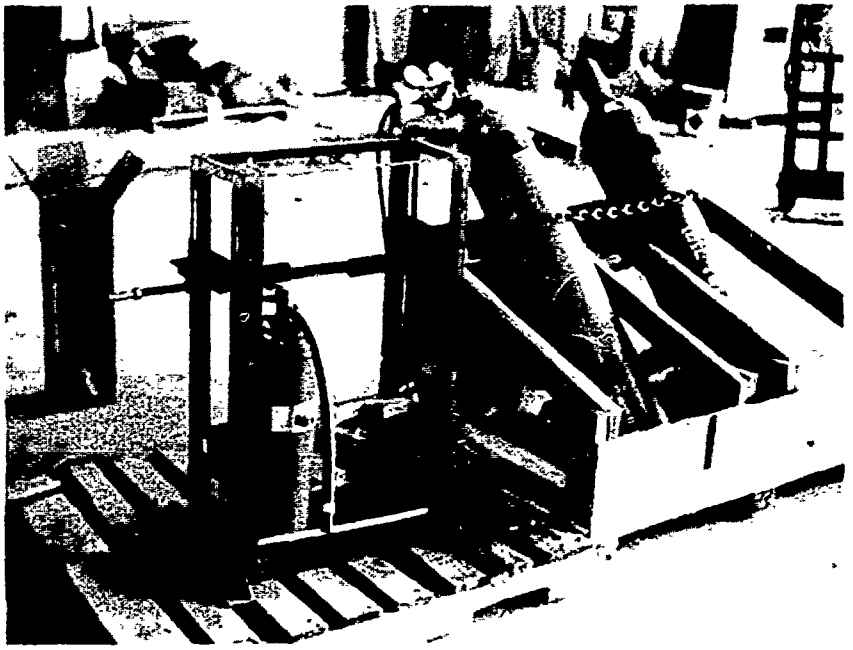


Figure 18. Repetitive Discharge Device

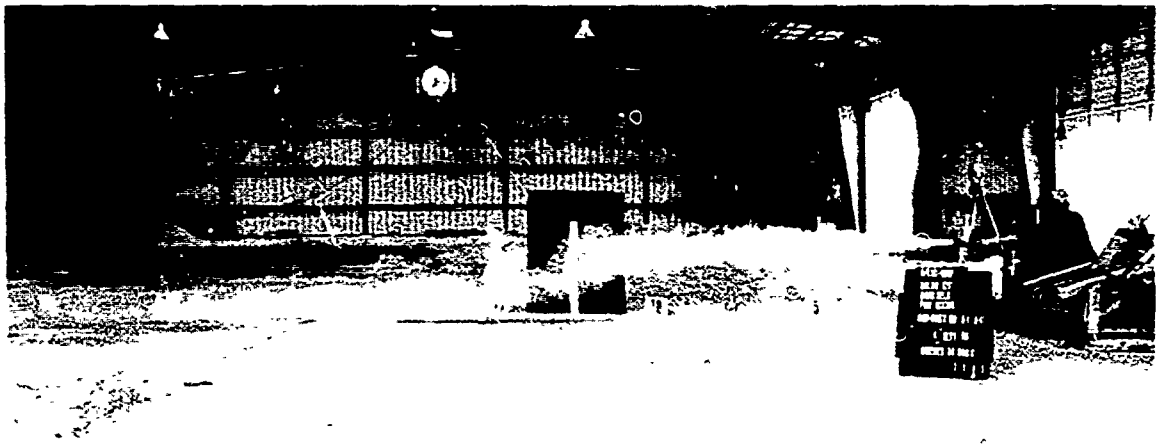


Figure 19. Establishment of Bascline For Discharge Characteristics

1211 filled extinguishers and the results compared with the initial baseline Halon test data established by the pre-test discharge. A photographic record of each extinguisher's initial and final discharge was produced for comparison purposes.

(c) Results

Results of this subtest are presented in Table 1, below.

TABLE 1. BASELINE DATA

10B:C EXTINGUISHERS

| | | THROW DISTANCE* FACTORY CHARGED (FT) | THROW DISTANCE RECHARGED (FT) | DISCHARGE TIME FACTORY CHARGED (SEC) | DISCHARGE TIME RECHARGED (SEC) | VARIATIONS IN ACTUATING PRESSURE (IN-LB) | LEAKAGE AFTER 23 RECHARGES |
|---|---|---|---|---|---|---|---|
| AMEREX | 1 | 13 | - | 10 | - | 0 | Could not recharge; threads in head bad. |
| | 2 | 13 | 13 | 10 | 10 | 10 | # |
| | 3 | 15 | 12 | 10 | 13 | 5 | # |
| | 4 | 13 | 12 | 11 | 10 | 5 | # |
| | 5 | 13 | 13 | 10 | 13 | 5 | # |
| | 6 | 13 | - | 10 | - | 0 | # |
| ANSUL | 1 | 8 | 15 | 20 | 16 | 3 | # |
| | 2 | 13 | 14 | 13 | 16 | 2 | # |
| | 3 | 13 | 15 | 13 | 15 | 3 | # |
| | 4 | 13 | 16 | 12 | 13 | 2 | # |
| | 5 | 15 | 16 | 15 | 14 | 0 | # |
| GRAVINER | 1 | 13 | - | 10 | - | 0 | Did not have the capability to recharge Graviner extinguishers. |
| | 2 | 13 | - | 11 | - | 0 | |
| | 3 | 13 | - | 11 | - | 0 | |
| | 4 | 13 | - | 10 | - | 0 | |
| | 5 | 8 | - | - | - | - | Valve stuck in open position. |
| FEMALL | 1 | 12 | 15 | 15 | 12 | 0 | # |
| | 2 | 20 | 12 | 13 | 13 | 0 | # |
| | 3 | 14 | 14 | 14 | 11 | 0 | # |
| | 4 | 15 | 15 | 15 | 11 | 0 | # |
| | 5 | 12 | 15 | 13 | 12 | 0 | # |
| | | | | 1A:10B:C EXTINGUISHERS | | | |
| AMEREX | 1 | 20 | 18 | 13 | 13 | 5 | # |
| | 2 | 14 | - | 11 | - | 2 | # |
| | 3 | 20 | 18 | 11 | 13 | 0 | # |
| | 4 | 20 | 18 | 12 | 15 | 0 | # |
| | 5 | 21 | 18 | 12 | 15 | 3 | # |
| | 6 | 18 | 15 | 12 | 18 | 5 | # |
| ANSUL | 1 | 17 | 18 | 12 | 15 | 0 | # |
| | 2 | 18 | 18 | 14 | 16 | 0 | # |
| | 3 | 14 | 18 | 13 | 13 | 10 | # |
| | 4 | 15 | 18 | 15 | 17 | 0 | # |
| | 5 | 17 | 18 | 13 | 16 | 0 | # |
| GRAVINER | 1 | 13 | - | 14 | - | 5 | Did not have the capability to recharge Graviner extinguishers. |
| | 2 | 13 | - | 11 | - | - | |
| | 3 | 13 | - | 11 | - | 7 | |
| | 4 | 14 | - | 11 | - | 0 | |
| | 5 | 15 | - | 10 | - | 0 | |
| FEMALL | 1 | 18 | 18 | 11 | 15 | 0 | # |
| | 2 | 15 | 17 | 14 | 13 | 0 | # |
| | 3 | 15 | 15 | 13 | 15 | 5 | # |
| | 4 | 15 | 17 | 13 | 12 | 0 | # |
| | 5 | 14 | 15 | 12 | 12 | 0 | # |

TABLE 1. BASELINE DATA (Continued)

| | | THROW DISTANCE* FACTORY CHARGED (FT) | THROW DISTANCE RECHARGED (FT) | DISCHARGE TIME FACTORY CHARGED (SEC) | DISCHARGE TIME RECHARGED (SEC) | VARIATIONS IN ACTUATING PRESSURE (IN-LB) | LEAKAGE AFTER 23 RECHARGES |
|---|---|---|---|---|---|---|---|
| **1A:10B:C EXTINGUISHERS (Continued)** | | | | | | | |
| PROTECTOSEAL | | | | | | | |
| | 1 | 20 | 18 | 15 | 12 | 18 | # |
| | 2 | 20 | 20 | 11 | 12 | 15 | # |
| | 3 | 20 | 20 | 10 | 13 | 2 | # |
| | 4 | 20 | 20 | 10 | 16 | 0 | # |
| | 5 | 20 | 20 | 12 | 13 | 0 | # |
| **2A:20B:C, 2A:40B:C, 2A:60B:C, AND 3A:80B:C EXTINGUISHERS** | | | | | | | |
| AMEREX | 1 | 20 | 20 | 25 | 29 | 0 | # |
| (3A:80B:C) | 2 | 20 | - | 25 | - | 0 | # |
| | 3 | 20 | 20 | 26 | 28 | 5 | # |
| | 4 | 20 | 20 | 24 | 26 | 0 | # |
| | 5 | 22 | 20 | 26 | 23 | 5 | # |
| ANSUL | 1 | 25 | 20 | 15.5 | 16 | 0 | # |
| (2A:40B:C) | 2 | 14 | 20 | 20 | 19 | 10 | # |
| | 3 | 22 | 20 | 15.5 | 16 | 8 | # |
| | 4 | 20 | 20 | 15 | 14 | 5 | # |
| | 5 | 20 | 20 | 15.5 | 15 | 0 | # |
| GRAVINER | 1 | 15 | - | 17.5 | - | 8 | Did not have |
| (2A:20B:C) | 2 | 15 | - | 17 | - | 10 | the capability |
| | 3 | 16 | - | 19 | - | 12 | to recharge |
| | 4 | 20 | - | 17 | - | 0 | Graviner |
| | 5 | 15 | - | 19 | - | 10 | extinguishers. |
| PEMALL | 1 | 15 | 17 | 17 | 20 | 5 | # |
| (2A:40B:C) | 2 | 18 | 18 | 19 | 24 | 0 | # |
| | 3 | 15 | 16 | 17 | 20 | 0 | # |
| | 4 | 15 | 20 | 21 | 19 | 0 | # |
| POTTER-ROEMER | | | | | | | |
| (2A:60B:C) | 1 | 20 | 21 | 20 | 21 | 0 | # |
| | 2 | 20 | 22 | 20 | 22 | 0 | # |
| | 3 | 22 | 20 | 21 | 23 | 0 | # |
| | 4 | 20 | 20 | 21 | 22 | 0 | # |
| | 5 | 20 | 20 | 20 | 21 | 0 | # |
| PROTECTOSEAL | | | | | | | |
| (2A:60B:C) | 1 | 15 | 22 | 18 | 23 | 5 | # |
| | 2 | 20 | 20 | 21 | 21 | 5 | # |
| | 3 | 18 | 20 | 20 | 22 | 5 | # |
| | 4 | 20 | 20 | 20 | 22 | 0 | # |
| | 5 | 22 | 20 | 26 | 25 | 2 | # |

*THROW DISTANCE - Distance from the nozzle at which the agent mist contacted the ground.

# - Satisfactory leak check.

(3) High Temperature

(a) Objective

This test was conducted in accordance with Procedure II of Method 501.1 of MIL-STD-810C, and was intended to approximate the exposure of equipment to cyclic high temperature stresses that may be encountered during storage and operational use on board military aircraft.

(b) Procedure

Before testing, all test items were operationally tested. recharged to manufacturer's specifications, and checked for leakage around O-rings and valve seals. Extinguishers were then placed inside a Branson Engineering Co. Model 4510-1N high temperature chamber (Figure 20) and placed under high temperature stress. The following temperature sequence was employed in testing.

1 Chamber temperature was raised from ambient to 120°F (49°C) and stabilized. Test extinguishers were then placed inside the test chamber. A temperature of 120°F (49°C) was then maintained for a period of 6 hours.

2 Chamber temperature was then raised from 120°F (49°C) to 160°F (71°C) and maintained for four hours.


Figure 20. Branson Engineering Co. Model 4510-1N High Temperature Chamber Containing Test Items

3 Chamber temperature was lowered from 160°F (71°C) to 120°F (49°C) within a period of 1 hour and then maintained at 120°F (49°C) for 6 hours. Steps 2 and 3 were then repeated twice more. Immediately upon completion of the cyclic temperature test sequence, the extinguishers were checked for leakage using the General Electric (GE) Tracker® II Freon Leak Detector. The extinguishers were then checked for proper operation. Post exposure tests established the extinguisher's ability to maintain pressure (leakage), operate satisfactorily at manufacturer's stated high temperature limit and reseal after partial discharge. Also included was an evaluation of hose materials and labels for deformation.

(c) Results

1 AMEREX - The Amerex extinguishers subjected to this test exhibited no problems in any of the areas of concern. This was true for all three sizes.

2 ANSUL - Two of the Ansul test items, one 1A:10B:C and one 2A:40B:C, showed a major defect when subjected to this test. These two extinguishers developed leaks in the static seal. The 1A:10B:C was completely empty by the end of the test. The 2A:40B:C had already leaked to such an extent that the pressure gauge was indicating below the operable level, and it continued leaking. The Ansul 10B:C extinguisher exhibited no problems. In other areas of concern, the Ansul extinguishers were satisfactory.

3 GRAVINER - Due to the complex recharge procedure required for the Graviner extinguishers, new (not pre-tested) extinguishers were tested. Most of the Graviner extinguishers had problems resealing after a partial discharge. They either did not reseal at all or were slow to reseal (after higher pressures were relieved). One 2A:20B:C expelled its contents out the top and rear of the handle, no agent passed through the nozzle. The Graviner extinguishers proved satisfactory in other areas of concern.

4 PEMALL - All three sizes of Pemall extinguishers selected for this test were satisfactory in all areas of concern.

5 POTTER-ROEMER - The Potter-Roemer extinguishers (2A:60B:C) were satisfactory in all areas of concern in this test.

6 PROTECTOSEAL - The two sizes of Protectoseal extinguishers tested were satisfactory in all areas of concern.

(4) Low Temperature Versus Altitude, Explosive Decompression, and Temperature Shock

(a) Objective

The objective of this test was to determine the ability of the test extinguishers to withstand and operate satisfactorily under simultaneously applied, varying conditions of low pressure and low temperatures such as would be encountered in normal aircraft operation. Air Force regulations require that fire fighting equipment be fully operable at all altitudes from sea level to 50,000 feet (Reference 9).

(b) Procedure

The low temperature altitude tests were conducted in the Strato-Chamber of the McKinley Climatic Laboratory, at Eglin Air Force Base, Florida (Figure 21).

Figure 21. Strato-Chamber of the McKinley Climatic Laboratory at Eglin Air Force Base, Florida

Prior to testing, each extinguisher was discharged completely, refilled to manufacturer's specifications, and tested for leakage with a GE Tracker® II Freon Leak Detector.

The Strato-Chamber was stabilized at -60°F and the test extinguishers were placed inside and held at a temperature of -60°F for a period of 4 hours. The chamber was then depressurized to a simulated altitude of 50,000 feet. The extinguishers were maintained at this altitude and temperature for 2 hours then slowly returned to ambient atmospheric pressure. The test extinguishers were then transferred to the chamber's lock. The Strato-Chamber was then depressurized to 62,500 feet at a temperature of -60°F and the lock was depressurized to 8,000 feet, also at the same temperature. A plastic window between the lock and chamber was broken to induce rapid decompression, resulting in an equalized altitude of 39,782 feet. The chamber was then lowered to ambient atmospheric pressure. The test articles were subjected to temperature shock by removal from the Strato-Chamber (-60°F) and placement in the open area adjacent to the McKinley laboratory (Figure 22) where the temperature remained at +95°F during post-test operational checks of the extinguishers.

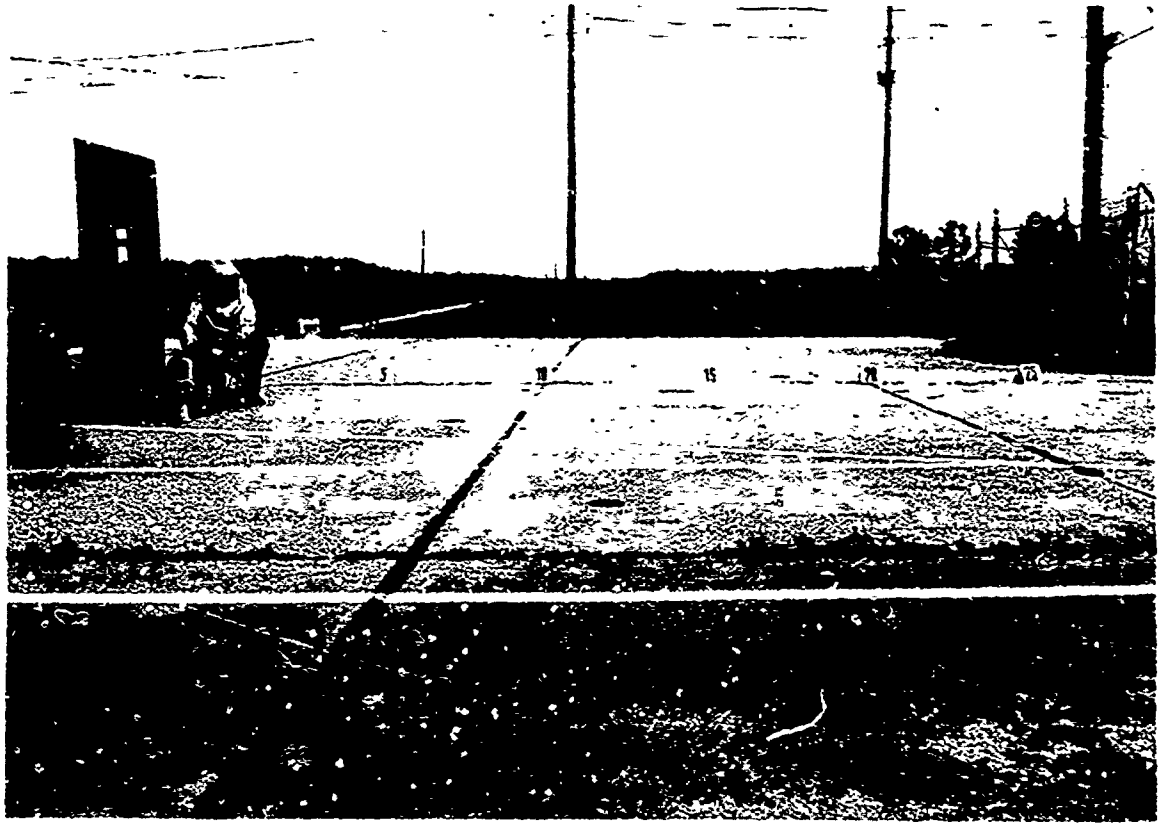


Figure 22. Test Items Being Subjected to Temperature Shock

Operational checks following the temperature shock exposure were conducted to determine:

- condition of O-rings or valve seals
- pressure readings
- discharge time
- throw distance
- discharge characteristics (liquid or gaseous state of agent)

(c) Results

Results are summarized in tabular format, below.

TABLE 2. POST-TEST PERFORMANCE

10B:C EXTINGUISHERS

LOW TEMPERATURE, ALTITUDE, EXPLOSIVE DECOMPRESSION, AND TEMPERATURE SHOCK

| | ITEM NUMBER | PRESSURE GAUGE AFTER EXPOSURE | THROW[1] DISTANCE (FT) | DISCHARGE[2] TIME (SEC) | AGENT DISCHARGE CHARACTERISTICS | POST EXPOSURE LEAKAGE |
|---|---|---|---|---|---|---|
| AMEREX | 1 | Green | 12 | 10 | # | No |
| | 2 | Green | 15 | 10 | # | No |
| | 3 | Low Green | 15 | 10 | # | No |
| ANSUL | 1 | 0 PSIG | 10 | 10 | W | No |
| | 2 | 0 PSIG | 8 | - | LD | No |
| | 3 | Green | 10 | 10 | # | No |
| | 4 | Green | - | - | W | No |
| | 5 | Green | 12 | 12 | # | No |
| PEMALL | 1 | Green | 15 | 10 | # | No |
| | 2 | Green | 15 | 9 | # | No |
| | 3 | Borderline Green/Red (Low) | 12 | 8 | # | No |

NFPA Standard -- Specification for Halon 1211 Extinguishers:

[1]Throw Distance (10B:C) - 9 to 15 feet

[2]Discharge Time (10B:C) - 8 to 15 seconds

Agent Discharge Characteristics: # - Satisfactory
W - Weak
LD - Liquid discharge

TABLE 2. POST-TEST PERFORMANCE (Concluded)

1A:10B:C EXTINGUISHERS

LOW TEMPERATURE, ALTITUDE, EXPLOSIVE DECOMPRESSION, AND TEMPERATURE SHOCK

| | ITEM NUMBER | PRESSURE GAUGE AFTER EXPOSURE | THROW[1] DISTANCE (FT) | DISCHARGE[2] TIME (SEC) | AGENT DISCHARGE CHARACTERISTICS | POST EXPOSURE LEAKAGE |
|---|---|---|---|---|---|---|
| AMEREX | 1 | Low Red | 15 | 12 | # | No |
| | 2 | 0 PSIG | - | - | LD | No |
| | 3 | Low Green | 12 | 11 | # | No |
| | 4 | 0 PSIG | 6 | - | LD | No |
| | 5 | 0 PSIG | - | - | LD | No |
| | 6 | Green | 15 | 13 | # | No |
| ANSUL | 1 | Green | 15 | 9 | # | No |
| | 2 | Green | 15 | 10 | # | No |
| | 3 | Green | 22 | 8 | # | No |
| | 4 | 0 PSIG | 10 | - | LD | No |
| GRAVINER | 1 | Green | 20 | 11 | # | No |
| | 2 | Green | 20 | 8 | # | No |
| | 3 | Green | ND | ND | | No |
| PEMALL | 1 | Green | 20 | 12 | # | No |
| | 2 | Green | 18 | 10 | # | No |
| | 3 | Green | 15 | 10 | # | No |
| PROTECTOSEAL | 1 | Green | 18 | 11 | # | No |
| | 2 | 0 PSIG | - | - | LD | Yes |
| | 3 | Low Red | 10 | - | LD | No |
| | 4 | Green | 15 | 10 | # | No |
| | | 2A:20B:C, 2A:40B:C, 2A:60B:C AND 3A:80B:C EXTINGUISHERS | | | | |
| AMEREX | 1 | Low Green | 20 | 28 | # | No |
| | 2 | Low Green | 18 | 28 | # | No |
| | 3 | 0 PSIG | - | - | LD | Yes |
| | 4 | 0 PSIG | - | - | LD | Yes |
| | 5 | 0 PSIG | 12 | - | W | Yes |
| ANSUL | 1 | Low Red | 20 | 14 | # | No |
| | 2 | Low Red | 23 | 14 | # | No |
| | 3 | Green | 20 | 12 | # | No |
| | 4 | Low Red | 20 | 13 | # | No |
| GRAVINER | 1 | Green | 20 | 15 | # | No |
| | 2 | Green | 20 | 16 | # | No |
| | 3 | Green | ND | ND | | No |
| | 4 | Green | ND | ND | | No |
| PEMALL | 1 | Green | 22 | 15 | # | No |
| | 2 | Green | 20 | 12 | # | No |
| | 3 | Green | 20 | 15 | # | No |
| | 4 | Low Red | 10 | - | LD | No |
| POTTER-ROEMER | 1 | 0 PSIG | 10 | - | LD | No |
| | 2 | Low Red | 10 | - | LD | No |
| | 3 | Green | 20 | 23 | # | No |
| | 4 | Green | 18 | 26 | # | No |
| PROTECTOSEAL | 1 | Green | 23 | 22 | # | No |
| | 2 | 0 PSIG | - | - | LD | No |
| | 3 | Green | 22 | 19 | # | No |
| | 4 | 0 PSIG | - | - | LD | Yes |
| | 5 | Borderline Green/Red (Low) | 20 | 23 | # | No |

ND - Not Discharged

NFPA Standard -- Specification for Halon 1211 Extinguishers:

[1]Throw Distance (1A:10B:C) - 9 to 15 feet
(2A:20-80B:C) - 14 to 16 feet

[2]Discharge Time (1A:10B:C) - 8 to 15 seconds
(2A:20-80B:C) - 10 to 18 seconds

Agent Discharge Characteristics: # - Satisfactory
W - Weak
LD - liquid discharge

(5) High Temperature Versus Altitude

(a) Objective

Similar in design to the low temperature versus altitude exposure (paragraph 2, (4), above), this test examined the extinguishers' ability to withstand the varying conditions of low pressures and high temperatures.

(b) Procedure

Pre-test data included refill and leak monitoring. Test items were placed inside the chamber and the chamber was brought to 150°F at one atmosphere. When the temperature was stabilized, the chamber conditions were then maintained for 30 minutes. The chamber was then decompressed to a simulated altitude of 40,000 feet over a period of approximately 10.5 minutes and maintained at this level for 30 minutes before returning the chamber to ambient atmospheric pressure. The chamber temperature was then lowered to 100°F and depressurized to a simulated altitude of 50,000 feet. These conditions were then maintained for 90 minutes before being rapidly compressed (1 min, 4 sec) to ambient atmospheric pressure. The test items were immediately checked for leakage, overpressurization and operational characteristics (discharge time and throw distance). Only extinguishers which exhibited problems during low temperature altitude exposure were evaluated for discharge characteristics; those showing no adverse effects were not discharged in order to conserve a dwindling supply of Halon 1211.

(c) Results

Post-exposure performance of the test articles is shown in Table 3, below.

TABLE 3. POST-TEST PERFORMANCE - HIGH TEMPERATURE, ALTITUDE

10B:C EXTINGUISHERS

| | ITEM NUMBER | PRESSURE GAUGE AFTER EXPOSURE | [1]DISCHARGE TIME (SEC) | POST EXPOSURE LEAKAGE | AGENT DISCHARGE CHARACTERISTICS |
|---|---|---|---|---|---|
| AMEREX | 1 | Green | ND | No | ND |
| | 2 | Green | ND | No | ND |
| | 3 | Green | ND | No | ND |
| ANSUL | 1 | Green | 15 | No | # |
| | 2 | High Green | 25 | No | # |
| | 3 | Green | 12 | No | # |
| | 4 | Green | ND | No | ND |
| | 5 | Green | ND | No | ND |
| PEMALL | 1 | Green | ND | No | ND |
| | 2 | Green | ND | No | ND |
| | 3 | Green | ND | No | ND |

ND - Not Discharged

[1]DISCHARGE TIME - NFPA Standard -- Specification for Halon 1211 Extinguishers:

10B:C - 8 to 15 seconds

Agent Discharge Characteristics: # - Satisfactory

TABLE 3. POST-TEST PERFORMANCE - HIGH TEMPERATURE, ALTITUDE (Concluded)

1A:10B:C EXTINGUISHERS

| | ITEM NUMBER | PRESSURE GAUGE AFTER EXPOSURE | [1]DISCHARGE TIME (SEC) | POST EXPOSURE LEAKAGE | AGENT DISCHARGE CHARACTERISTICS |
|---|---|---|---|---|---|
| AMEREX | 1 | Green | ND | No | ND |
| | 2 | Green | 21 | No | # |
| | 3 | Green | ND | No | ND |
| | 4 | Green | 12 | No | # |
| | 5 | Green | 17 | No | # |
| | 6 | Green | ND | No | ND |
| ANSUL | 1 | Green | ND | No | ND |
| | 2 | Green | ND | No | ND |
| | 3 | Green | ND | No | ND |
| GRAVINER | 1 | Green | ND | No | ND |
| PEMALL | 1 | Green | 15 | No | # |
| | 2 | Green | ND | Yes* | ND |
| | 3 | Green | ND | No | ND |
| PROTECTOSEAL | 1 | Green | ND | No | ND |
| | 2 | Green | 15 | No | |
| | 3 | Green | ND | No | ND |
| | 4 | Green | ND | No | ND |

2A:20B:C, 2A:40B:C, 2A:60B:C AND 3A:80B:C EXTINGUISHERS

| | | | | | |
|---|---|---|---|---|---|
| AMEREX | 1 | Green | ND | No | ND |
| (3A:80B:C) | 2 | Green | ND | No | ND |
| | 3 | Green | 20 | No | # |
| ANSUL | 1 | Green | ND | No | ND |
| (2A:40B:C) | 2 | Green | ND | No | ND |
| | 3 | Green | ND | No | ND |
| | 4 | Green | ND | Yes | ND |
| GRAVINER | 1 | Green | ND | No | ND |
| (2A:20B:C) | 2 | Green | ND | No | ND |
| PEMALL | 1 | Green | ND | No | ND |
| (2A:40B:C) | 2 | Green | ND | No | ND |
| | 3 | Green | ND | No | ND |
| | 4 | Green | ND | No | ND |
| POTTER-ROEMER | 1 | Green | 27 | No | # |
| (2A:60B:C) | 2 | Green | 27 | No | # |
| | 3 | Green | ND | No | ND |
| | 4 | Green | ND | No | ND |
| PROTECTOSEAL | 1 | Green | ND | No | ND |
| (2A:60B:C) | 2 | Green | 22 | No | # |
| | 3 | Green | ND | Yes | ND |
| | 4 | Green | 30 | No | # |
| | 5 | Green | ND | No | # |

ND - Not Discharged

[1]DISCHARGE TIME - NFPA Standard--Specification for Halon 1211 Extinguishers:

1A:10B:C - 8 to 15 seconds

2A:20-80B:C - 10 to 18 seconds

Agent Discharge Characteristics: # - Satisfactory

*Pressure gauge damaged by chamber fire.

(6) Vibration

(a) Objective

The vibration tests were performed to determine if extinguishers and their associated mounting brackets were able to withstand expected dynamic vibrational stresses and to ensure that performance degradations or malfunctions will not be produced by the vibrational environment of the aircraft in which the extinguisher is mounted.

(b) Procedure

Prior to the test, extinguishers were charged to manufacturer's specifications and checked for leaks with the GE Tracker® II Freon Detector.

The test apparatus was a electro-dynamic shaker, (Unholtz-Dickie Corporation, Model T512A, Serial Number 169) located in the Fuze Test Facility of the McKinley Climatic Laboratory, Eglin Air Force Base, Florida.

The charged extinguisher was mounted to the vibrator by means of its mounting bracket with the long axis of the extinguisher in a horizontal position (Figure 23). A frequency survey was conducted with varied

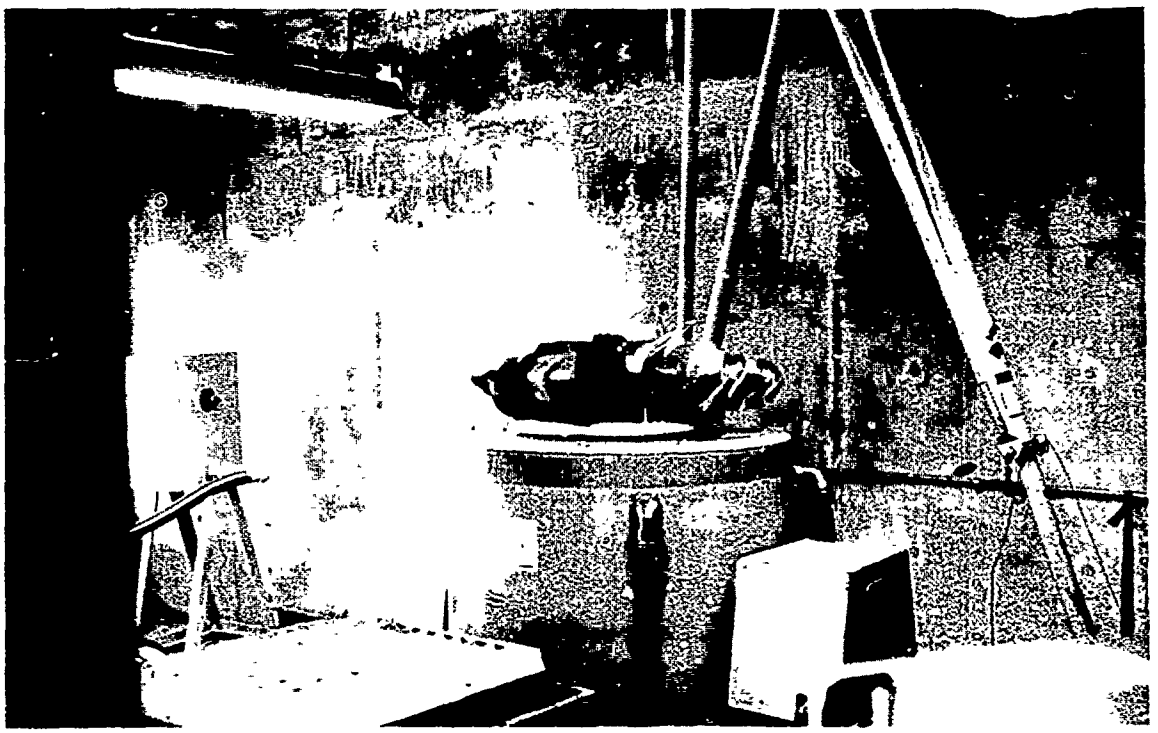


Figure 23. Charged Extinguishers Mounted to Vibrator

double amplitudes and frequencies to produce the most severe conditions which could be encountered during the service life of the extinguisher. The amplitude selected for this test was 0.95 inch with a frequency of 11 Hz, equivalent to 5.8 g. Duration of exposure was 30 minutes for the extinguisher, while extinguisher brackets saw a total of 6 hours of cumulative vibration.

Following vibratory testing, the extinguishers were checked for leakage and then discharged to ascertain their operational characteristics.

(c) Results

The results of extinguisher and mounting bracket performance in the vibration tests are shown below.

1 Results of post-test discharge of extinguishers are given in Table 4, below.

TABLE 4. POST-TEST PERFORMANCE - VIBRATION

10B:C EXTINGUISHERS

| | ITEM NUMBER | DISCHARGE[1] TIME (SEC) | POST EXPOSURE LEAKAGE | AGENT DISCHARGE CHARACTERISTICS | REMARKS |
|---|---|---|---|---|---|
| AMEREX | 1 | 15 | No | # | Nozzle/valve gasket leak. |
| | 2 | 15 | No | # | |
| | 3 | 15 | Yes* | #, DR | *Leak due to bracket failure. |
| ANSUL | 1 | 13.6 | No | W, DR | |
| | 2 | 13.7 | No | #, DR | |
| | 3 | 12.5 | No | #, DR | |
| | 4 | 15.5 | No | # | |
| PEMALL | 1 | 15 | No | #, DR | |
| | 2 | 13 | No | #, DR | |
| | 3 | 15 | No | #, DR | |

[1]DISCHARGE TIME - NFPA Standard — Specification for Halon 1211 Extinguishers:

10B:C - 8 to 15 seconds

Agent Discharge Characteristics: # - Satisfactory
W - Weak
DR - Liquid agent drip at nozzle

TABLE 4. POST-TEST PERFORMANCE - VIBRATION (Concluded)

1A:10B:C EXTINGUISHERS

| | ITEM NUMBER | DISCHARGE[1] TIME (SEC) | POST EXPOSURE LEAKAGE | AGENT DISCHARGE CHARACTERISTICS | REMARKS |
|---|---|---|---|---|---|
| AMEREX | 1 | 16 | No | # | |
| | 2 | 15.3 | No | # | |
| | 3 | 18 | No | # | |
| | 4 | 12 | No | # | |
| | 5 | 13 | No | # | Leaked liquid agent at nozzle/valve seal. |
| | 6 | 16 | No | # | Vibrated 2-1/2 hours. |
| ANSUL | 1 | 17 | No | #, SP | |
| | 2 | 21 | No | #, DR, SP | |
| GRAVINER | 1 | 11 | No | #, DR | |
| PEMALL | 1 | 18 | No | #, DR | |
| | 2 | - | No | # | Leaked liquid agent at hose/valve seal. |
| PROTECTOSEAL | 1 | 12 | No | # | |
| | 2 | 16 | No | #, SP | |
| | 3 | 15 | No | # | |

2A:20B:C, 2A:40B:C, 2A:60B:C, 3A:80B:C EXTINGUISHERS

| | | | | | |
|---|---|---|---|---|---|
| AMEREX (3A:80B:C) | 1 | 27 | No | # | |
| | 2 | 27 | No | # | |
| ANSUL (2A:40B:C) | 1 | 18 | No | # | |
| | 2 | 18 | No | # | |
| | 3 | 18 | No | #, DR | |
| GRAVINER (2A:20B:C) | 1 | 19 | No | # | |
| PEMALL (2A:40B:C) | 1 | 14 | No | #, DR | |
| | 2 | 23.5 | No | # | Leaked agent at hose/valve seal. |
| | 3 | 16 | No | # | Leaked agent at hose/valve seal. |
| POTTER-ROEMER (2A:60B:C) | 1 | 20.3 | Yes | # | |
| | 2 | 23 | No | # | |
| | 3 | 27.6 | No | W | Agent leaked at hose/valve seal. |
| | 4 | 29 | Yes | # | |
| PROTECTOSEAL (2A:60B:C) | 1 | 25 | No | # | Agent leaked at hose/valve seal. |

[1]DISCHARGE TIME - NFPA Standard -- Specificatio for Halon 1211 Extinguishers:

1A:10B:C - 8 to 15 seconds

2A:20-80B:C - 10 to 18 seconds

Agent Discharge Characteristics: # - Satisfactory
SP - Slight Pulse
DR - Liquid agent drip at nozzle
W - Weak

2 Mounting Brackets

a Bracket 809

Within the first hour of testing, the upper stand-off brace collapsed. A new model 809 bracket was installed with hard rubber spacers placed under top and bottom stand-offs.

No cushions were lost during 6 hours of vibration, although they did show considerable wear. There was much less compression of the stand-offs than in Model 810, below. Some chipping of paint was noted.

b Bracket 810

As with Model 809, the top stand-off brace collapsed within the first hour of vibration. A new 810 was installed with rubber spacers under top and bottom stand-offs for added support.

At 1 hour 26 minutes of vibration, one of the rubber cushions broke loose causing the extinguisher to shake severely, causing a sizable dent in the extinguisher cylinder.

At 3 hours 37 minutes, Model 810 lost another cushion; 4 hours 30 minutes, another cushion was lost.

After 6 hours vibration, Model 810 had lost a total of 6 rubber cushions. With modification (rubber spacers), there was a slight deformation of stand-off braces and paint chipping.

Model 810 was too short for large extinguishers (Amerex 3A:80B:C, Protectoseal 2A:60B:C, Potter-Roemer 2A:60B:C and Graviner 2A:20B:C); strap was below these extinguishers' center of gravity.

c Bracket 818

This bracket accommodates the Amerex 10B:C extinguisher.

At 2 hours 4 minutes of vibration, the metal strap broke at the rivet which holds it to the back brace. Up to the point of failure, the bracket performed satisfactorily. When the strap broke, the extinguisher was thrown from the vibrating machine and damaged. The painted surface showed wear at locations where the extinguisher made contact with the bracket.

d Bracket 821

Two brackets withstood 6 hours of sustained vibration with only minor deficiencies noted. Rubber spacers had collapsed and paint had worn off on the bracket's back plate.

e Small Pemall Bracket

This bracket was designed to be used with 10B:C Pemall extinguisher. The bracket features 2 straps. A small sponge rubber pad attached to the back brace proved ineffective, allowing the extinguisher to rotate, scratching paint from the cylinder body.

After vibrating for 1 hour 12 minutes, the bottom strap broke at the rivet attaching it to the back brace. The top strap held the extinguisher in place until vibration could be stopped.

f Medium Pemall Bracket

Without modification, the bracket could not hold securely the extinguisher for which it was designed (1A:10B:C). The modification consisted of rubber spacers placed between the extinguisher and bracket strap.

After 3 hours of vibration, considerable wear and stretch at the hinge holding strap was noted. Additional spacers had to be installed to permit continuation of testing.

At the conclusion of testing, after 5.5 hours of exposure, more stretching of the strap at the hinge had taken place. Paint wear and chipping was evident.

g Large Pemall Bracket

This bracket was unable to hold the extinguisher off the mounting surface. During vibration, extinguishers suffered abrasive wear at the point where contact was made with the mounting surface. Rubber cushioning pads, installed with an adhesive backing, separated during the early stage of vibration exposure.

After 6 hours of vibration, the bracket had retained its structural integrity; however, there was some wear and chipping of the paint.

(7) Salt Fog

(a) Objective

The salt fog test was conducted to determine the resistance of extinguishers and their associated brackets to the effects of salt atmosphere. Areas of concern were: operation of valves, safety devices, bracket clamps, and the post-exposure condition of protective finishes of extinguishers and brackets.

(b) Procedure

Pre-test of the extinguishers included an operational check, recharging with nitrogen and check for leakage. Method 509.1 of MIL-STD-810C served as the guide for the test design. One extinguisher of each size from each manufacturer was selected for this test.

The test chamber used was a wood (epoxy coated) and fiberglass tank, 36 inches deep x 23 inches wide x 29 inches long (Figure 24).

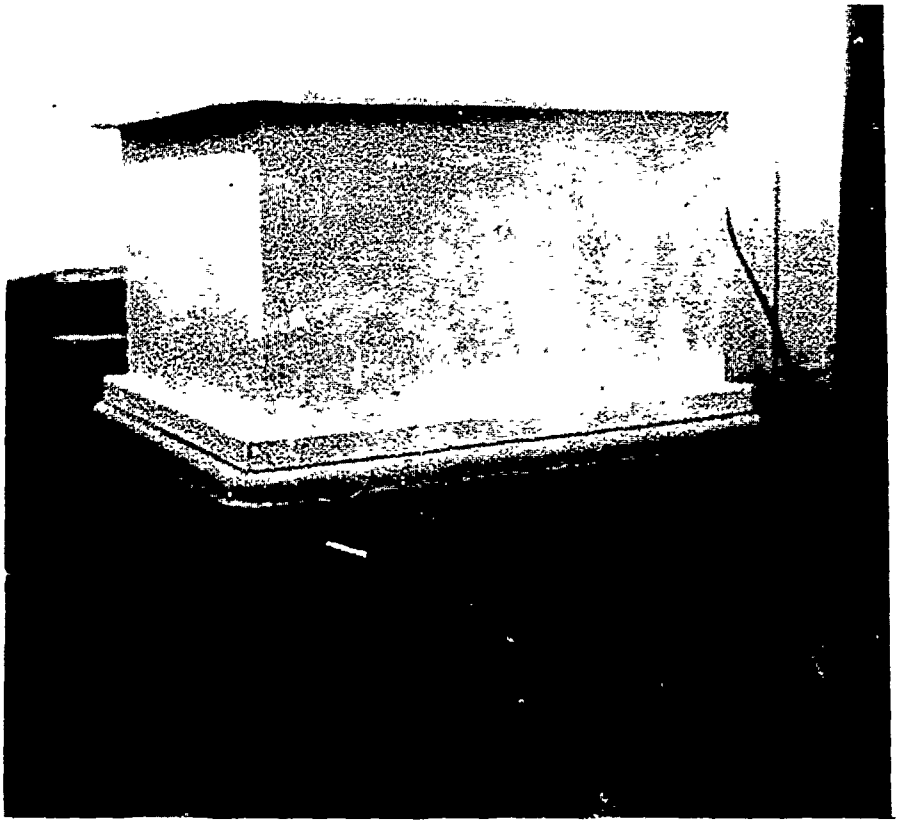


Figure 24. Salt Fog Chamber

To control temperature and humidity, this fog chamber was placed inside an environmental chamber (BioTemp Scientific, Inc., Model FR-912). Chamber temperature was maintained at 35°C with a relative humidity of at least 85 percent.

The salt fog was derived by atomizing a 5 percent sodium chloride solution with a pH range of 6.5 to 7.2.

Collection receptacles were placed in the fog chamber at random locations to collect fog residue for sodium chloride content and pH measurements at the end of the test. Sodium chloride content measurement was made with a temperature compensated Goldberg Refractometer manufactured by American Optical. The pH was measured electrometrically with an Orion Model 404 Selective Ion Meter. The instruments were calibrated prior to each use.

The test consisted of exposing the fire extinguishers to an intermittent salt fog for a duration of 200 hours (Figure 25).

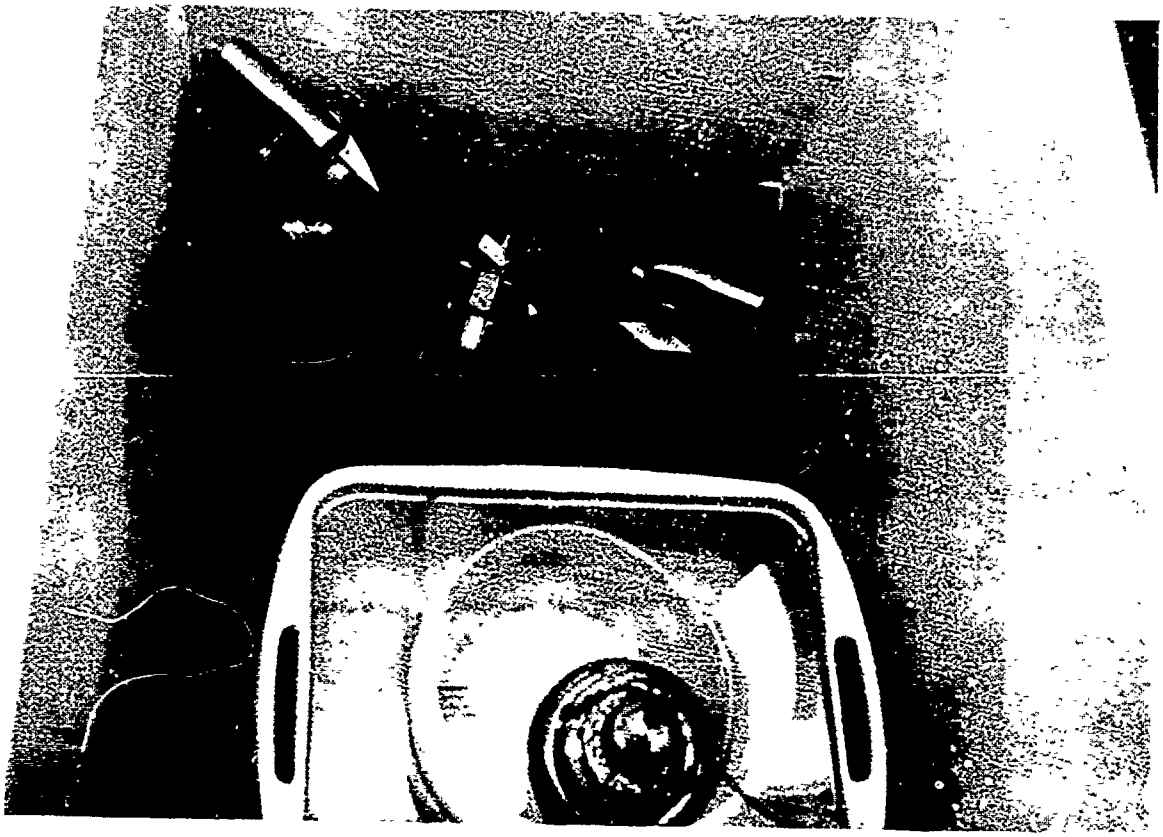


Figure 25. Salt Fog Test

The amount of NaCl atomized in 24 hours was 3375 ml. At the end of this period the extinguishers were rinsed with fresh water and allowed to stand at room temperature for an additional 48 hours.

At the termination of the salt fog, solutions collected in the collection receptacles were measured for sodium chloride content and pH.

After 48 hours at ambient room temperature the test items were examined for rust on cylinders and brackets and for corrosion on valves, safety devices, and hose fittings. Valves were operated as well as the quick release mechanisms on the brackets.

(c) Results

1 Extinguisher Post-Test Evaluation

a AMEREX

10B:C - The extinguisher's cylinder showed slight rust at the valve/neck seal. The remaining portion of the cylinder had no rust. There was no corrosion on the valve body or nozzle, and valve operation was satisfactory. The salt atmosphere had no effect on the extinguisher's label.

1A:10B:C - The extinguisher's cylinder had no visible rust or corrosion. The valve body was also free from corrosion and valve operation was satisfactory. There were slight rust spots on the valve actuating lever and handle. The hose and hose fittings, as well as the label, displayed no effect from this test.

3A:80B:C - The extinguisher's cylinder had slight rust at the valve/neck seal. The rest of the cylinder was rust free. The valve body had no corrosion and operation was satisfactory. There was slight rust on the valve actuating lever and handle. The hose, hose fittings, and label were in satisfactory condition.

b ANSUL

10B:C - The cylinder had slight rust at the neck weld and at the valve/neck seal. The cylinder body was rust free. The valve head and handles had no corrosion and operated satisfactorily. The labels showed no effect from this test.

1A:10B:C - The cylinder had slight rust at the neck weld and at the valve/neck seal. The cylinder body was rust free. There was no corrosion on the valve head or handles and operation was satisfactory. The hose, hose fittings, and labels were in satisfactory condition.

2A:40B:C - The cylinder had slight rust at the valve/neck. The cylinder body was free of any rust. The valve head and handles had no corrosion or rust. The hose, hose connections, and labels were in satisfactory condition.

c GRAVINER

10B:C - The cylinder had slight rust at the midseam and at the bottom boot seam. There was also slight rust at the neck/cylinder interface. The valve exterior and handle were corrosion free. The design of the valve head allowed salt spray to enter the top portion of the valve head assembly. There were salt deposits in this portion of the valve head. The flat spring inside the head was slightly corroded. The safety pin was stiff to remove. Valve operation was satisfactory and no problems were noticed with the hose, hose connection, or label.

1A:10B:C, 2A:20B:C - The cylinder had slight rust at the mid-seam and bottom boot seam. There was no corrosion on the exterior of the valve body. As with the 10B:C, salt spray entered the top portion of the valve head assembly. Salt deposits were present here and the flat valve spring was slightly corroded. The safety pin was stiff to remove. Valve operation was satisfactory as were hose, hose connections, and label.

d PEMALL

10B:C - The extinguisher cylinder had small rust spots on the shoulder; the rest of the cylinder was satisfactory. There was no corrosion on the valve body or handles. Valve operation was satisfactory. There was slight corrosion on the pressure gauge stem. The nozzle and label displayed no problems.

1A:10B:C - There was rust at the mid-seam of the cylinder and somewhat more at the bottom boot seam. The remainder of the cylinder was satisfactory. The valve body had no corrosion and operation was satisfactory. The hose fittings were quite extensively corroded. The aluminum fittings are secured with brass sleeves. In the presence of an electrolyte, corrosion of the anodic aluminum is accelerated. The hose and label were in good condition.

2A:40B:C - There was no rust on the cylinder. The valve body was corrosion free, and operation was satisfactory. The hose fittings were corroded as in the 1A:10B:C extinguisher. The hose and label were in good condition.

e POTTER-ROEMER

2A:60B:C - The cylinder had rust at the valve/neck seal. The cylinder body remained in good condition. There were slight rust spots on the valve handles. The valve body had no corrosion, and operation was satisfactory. The hose, hose fittings and label were satisfactory.

f PROTECTOSEAL

1A:10B:C - The cylinder had rust at the neck/bottle joint and the valve/neck seal. The valve handles had some slight rust spots. There was no corrosion on the valve body and operation was satisfactory. There was condensation inside the pressure gauge; operation remained satisfactory. The hose, hose fittings, and label remained in good condition.

2A:60B:C - This cylinder had rust at the neck/cylinder joint and valve/neck seal. There was also some rust at the hanger welds. The remainder of the cylinder was in good condition. The valve handles had some small rust spots. There was no corrosion on the valve body and operation was satisfactory. There were no problems with the hose, hose fittings, or label.

2 Sodium chloride solution characteristics resulting from exposure of the salt fog are given in Table 5, below.

TABLE 5. SODIUM CHLORIDE SOLUTION CHARACTERISTICS

| | PRE-TEST | | | POST-TEST* | | |
|---|---|---|---|---|---|---|
| | pH | REFRACTIVE INDEX | NaCl % | pH | REFRACTIVE INDEX | NaCl % |
| AMEREX | 6.7 | 1.3416 | 4.91 | 5.5 | 1.3423 | 5.31 |
| ANSUL | 7.0 | 1.3418 | 5.03 | 4.2 | 1.3433 | 5.88 |
| GRAVINER | 6.6 | 1.3414 | 4.79 | 5.3 | 1.3424 | 5.37 |
| PEMALL | 6.7 | 1.3415 | 4.85 | 4.7 | 1.3431 | 5.77 |
| PROTECTOSEAL AND POTTER-ROEMER | 6.5 | 1.3418 | 5.03 | 6.8 | 1.3426 | 5.48 |

* Post-Test characteristics are averaged from three collection sites within the fog chamber.

3 Bracket Post-Test Evaluation

a AMEREX

818 - There was slight rust at rivet attaching the strap to the back plate. Operation of the cam lock was satisfactory.

809 - There was excessive rust at the seams, edges and other places where the paint was loose or removed. Rust was excessive on the adjustment bolt and nuts. With the present finish (paint), excessive maintenance would be required. Operation of the cam lock remained satisfactory.

810 - There was excessive rust at the seams, edges and other areas where paint was loose or removed. Rust was especially heavy on the adjustment bolt and nuts. Excessive maintenance would be required if the existing finish (paint) was used. Operation was satisfactory.

b PEMALL

Small (10B:C) - On the back plate there was slight rust at the edges in the neck yoke and at areas where paint was loose or removed. Operation was satisfactory.

Medium (1A:10B:C) - There was excessive rust at the seams, edges, and areas where paint was loose or removed. There was also rust at the strap hinge. Although rust on the hinge made operation somewhat stiffer than normal, operation was satisfactory. A longer exposure could make operation extremely difficult. Excessive maintenance would be required if the present finish (paint) was used.

Large (?A:40B:C) - The large Pemall bracket showed the same effects as the medium size bracket.

(8) Acceleration

(a) Objective

The acceleration test was performed to determine if Halon 1211 fire extinguishers and associated brackets could withstand expected steady state stresses and to detect any performance degradations or malfunctions likely to be produced by the simulated service acceleration environment. Both structural and operational tests were conducted.

(b) Procedure

Extinguishers were discharged to establish pre-test baseline data, then recharged, according to manufacturer's specification, and checked for leaks with the GE Tracker® II Freon Leak Detector. The test setup consisted of an AFESC designed centrifuge with a 2-foot radius swing arm, and a tachometer from Metron Instruments, Inc., Type 26B.

Two extinguishers of each size and manufacturer were subjected to acceleration tests.

Procedure V (operational) and Procedure I (structural) from Method 513.2 of MIL-STD-810C (Reference 9) were followed for the conduct of these tests.

(c) Operational Test

Operational tests were conducted for an inward lateral acceleration that kept the extinguishers in an upright position (Figure 26).

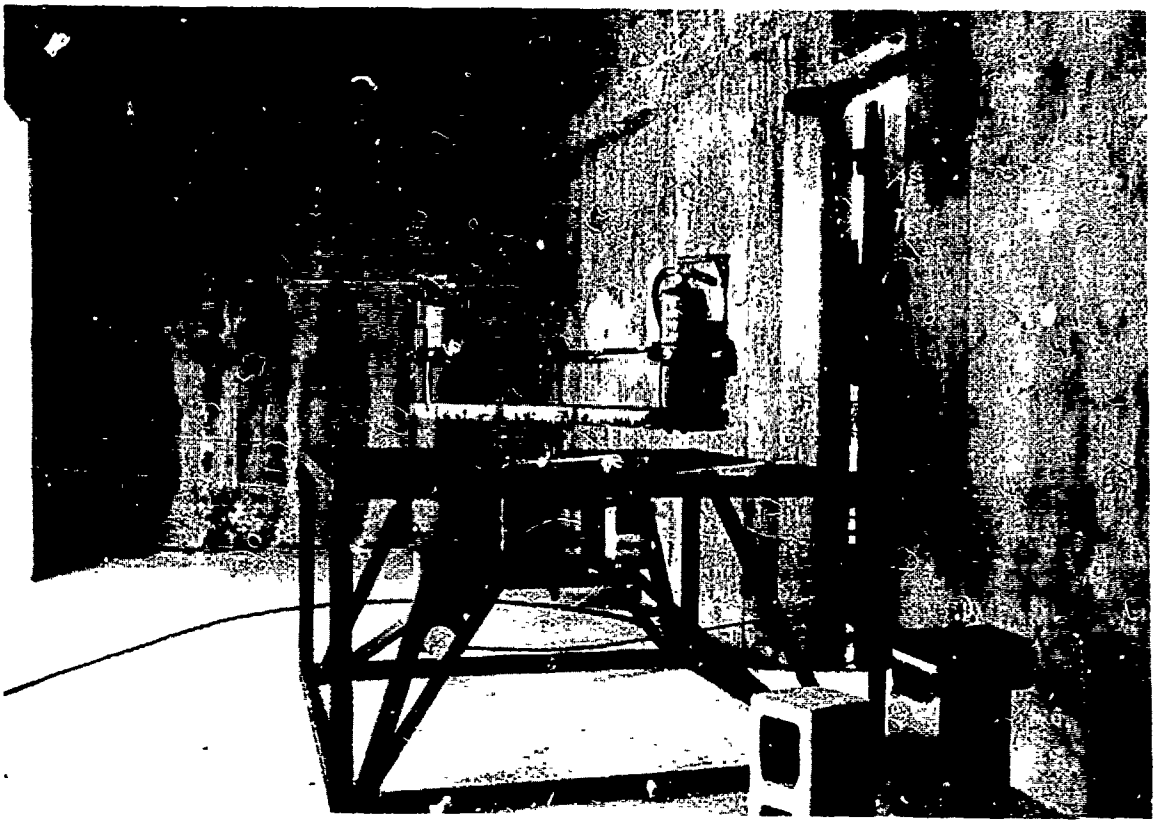


Figure 26. Inward Lateral Acceleration Test

The inward lateral direction assumes that the extinguisher is mounted upright on an exterior sidewall of an aircraft. This is the only position in which the extinguishers will operate properly. The level of 9.0 g required by Reference 9 was attained by 115 rpm. When the required g-level was reached and maintained for 1 minute, the extinguishers were remotely operated by electric solenoids; and the test item's operational characteristics were observed and recorded.

(d) Structural Tests

Structural tests were conducted for outward lateral (Figure 27), upward, and downward acceleration (Figure 28). Reference 9 established the following g-levels: 9.00 g for outward lateral acceleration, 13.5 g for upward acceleration, and 4.5 g for downward acceleration.

When the rpm to achieve the required g-level was attained, the speed was maintained for a duration of 1 minute.

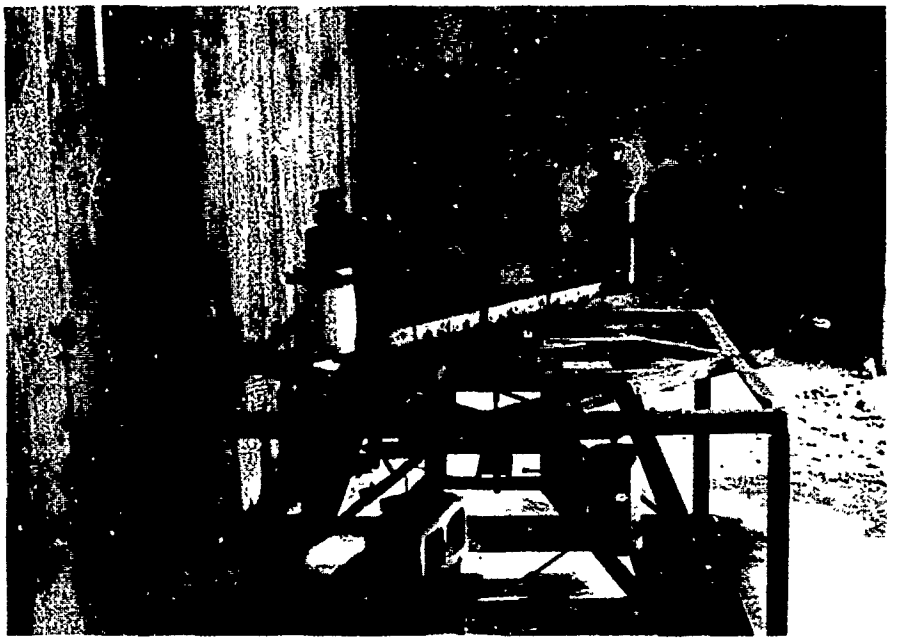


Figure 27. Outward Lateral Acceleration Test

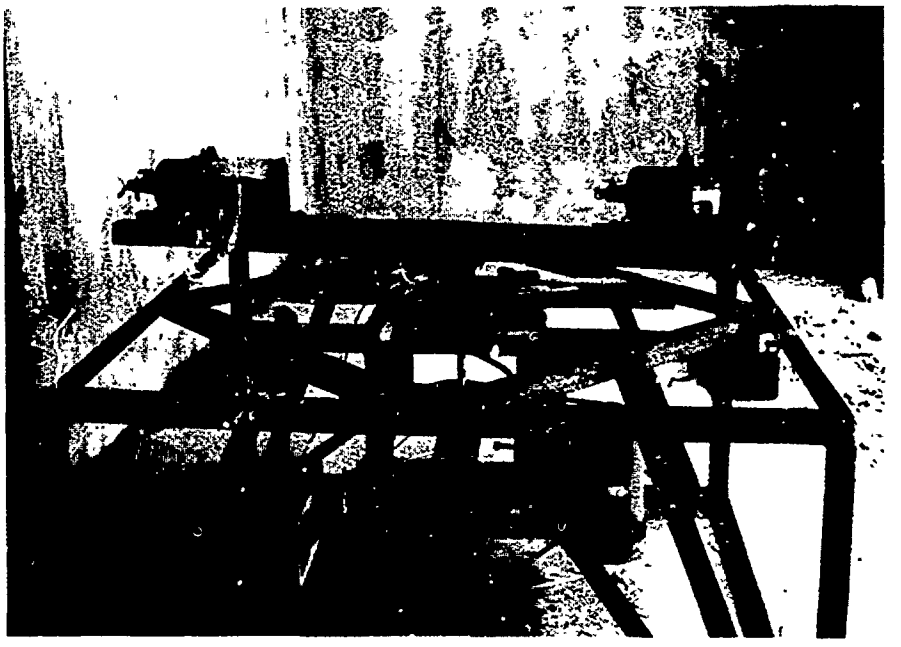


Figure 28. Upward and Downward Acceleration Test

Two extinguishers of each size from each manufacturer were tested in the outward lateral direction. One extinguisher of each size was tested in the upward and downward acceleration direction. These tests were performed simultaneously (Figure 28).

The structural test sequence established the extinguisher bracket's integrity in relation to its mounting means and tested its ability to securely hold the fire extinguisher. Fire extinguishers were checked for leaks after each structural test and operated after the final (upward/downward) acceleration test.

(e) Operational Test Results

10B:C - Amerex, Ansul, Pemall.

Two extinguishers from each manufacturer were tested for satisfactory operation at 9.0 g in an inward lateral direction. All 10B:C extinguishers tested operated satisfactorily at specified g-level.

1A:10B:C - Amerex, Ansul, Pemall, Protectoseal

Two extinguishers from each manufacturer were tested. All 1A:10B:C extinguishers operated satisfactorily at the specified g-level.

2A:40B:C, 2A:60B:C, 3A:80B:C - Amerex, Ansul, Pemall, Potter-Roemer, and Protectoseal

Two extinguishers from each manufacturer were tested. The Ansul and Pemall extinguishers operated satisfactorily at 9.0 g. The Amerex, Potter-Roemer, and Protectoseal failed to operate satisfactorily at 9.0 g. At this acceleration level, only nitrogen was expelled during discharge. Acceleration had to be reduced to 5.2 g before these extinguishers would operate properly.

(f) Structural Test Results

Results of the structural acceleration tests are shown in Tables 6, 7, and 8.

TABLE 6. ACCELERATION - OUTWARD LATERAL, 9.0 G

10B:C EXTINGUISHERS AND BRACKETS

| | POST TEST LEAKAGE | POST TEST OPERATION | POST OPERATION LEAKAGE | BRACKET MOD. NO. | BRACKET PERFORMANCE |
|---|---|---|---|---|---|
| AMEREX | # | # | # | 818 | Bracket failed at 7.8 g. Clamp separated from strap. |
| | # | # | # | 818 | # |
| | - | - | - | 821 | # |
| ANSUL | # | # | # | 809 | # |
| | # | # | # | 809 | # |
| PEMALL | # | # | # | Sm. Pemall | Bracket loosened, did not fail. |
| | # | # | # | Sm. Pemall | Bracket loosened, did not fail. |

1A:10B:C EXTINGUISHERS AND BRACKETS

| | | | | | |
|---|---|---|---|---|---|
| AMEREX | # | # | # | 809 | # |
| | # | # | # | 809 | # |
| ANSUL | # | # | # | 809 | # |
| | # | # | # | 809 | # |
| PEMALL | # | # | # | 809 | # |
| | # | # | # | 809 | # |
| PROTECTOSEAL | # | # | # | 809 | # |
| | # | # | # | 809 | # |

2A:20B:C, 2A:40B:C, 2A:60B:C, 3A:80B:C EXTINGUISHERS AND BRACKETS

| | | | | | |
|---|---|---|---|---|---|
| AMEREX | # | # | # | 810 | Bracket loosend slightly. |
| (3A:80B:C) | - | # | - | 810 | # |
| ANSUL | # | # | # | Mod. 809* | # |
| (2A:40B:C) | # | # | # | Mod. 809* | # |
| PEMALL | # | # | # | Lg. Pemall | Deformed cam lock, could not use for further tests. |
| POTTER ROEMER | # | # | # | 810 | # |
| (2A:60B:C) | # | # | # | 810 | |
| PROTECTOSEAL | # | # | # | 810 | Bracket loosened slightly. |
| (2A:60B:C) | # | # | # | 810 | Bracket loosened slightly. |

# - Satisfactory performance.

* A longer adjustment bolt was added to the 809 Bracket to accommodate a larger diameter extinguisher.

TABLE 7. ACCELERATION - UPWARD, 13.5 G

10B:C EXTINGUISHERS AND APPROPRIATE BRACKETS

| | POST TEST LEAKAGE | POST TEST OPERATION | POST OPERATION LEAKAGE | BRACKET MOD. NO. | BRACKET PERFORMANCE |
|---|---|---|---|---|---|
| AMEREX | # | # | # | 818 | # |
| | - | - | - | 821 | # |
| ANSUL | # | # | # | 809 | # |
| PEMALL | # | # | # | Sm. Pemall | Neck yoke bent down slightly. |

1A:10B:C EXTINGUISHERS AND BRACKETS

| | | | | | |
|---|---|---|---|---|---|
| AMEREX | # | # | # | 809 | # |
| ANSUL | # | # | # | 809 | # |
| PEMALL | # | # | # | 809 | # |
| PROTECTOSEAL | # | # | # | 809 | # |

2A:20B:C, 2A:40B:C, 2A:60B:C, 3A:80B:C EXTINGUISHERS AND ASSOCIATED BRACKETS

| | | | | | |
|---|---|---|---|---|---|
| AMEREX | # | # | # | 810 | # |
| ANSUL | # | # | # | Mod. 809* | # |
| PEMALL | - | - | - | - | - |
| POTTER ROEMER | # | # | # | 810 | # |
| PROTECTOSEAL | # | # | # | 810 | # |

# - Satisfactory performance.

*A longer adjustment bolt was added to the 809 Bracket to accommodate a larger diameter extinguisher.

TABLE 8. ACCELERATION - DOWNWARD, 4.5 G

10B:C EXTINGUISHERS AND BRACKETS

| | POST TEST LEAKAGE | POST TEST OPERATION | POST OPERATION LEAKAGE | BRACKET MOD. NO. | BRACKET PERFORMANCE |
|---|---|---|---|---|---|
| AMEREX | # | # | # | 818 | Neck yoke bent up slightly. |
| | # | # | # | 821 | # |
| ANSUL | # | # | # | 809 | # |
| PEMALL | # | # | # | Sm. Pemall | # |

1A:10B:C EXTINGUISHERS AND BRACKETS

| | | | | | |
|---|---|---|---|---|---|
| AMEREX | # | # | # | 809 | # |
| ANSUL | # | # | # | 809 | # |
| PEMALL | # | # | # | 809 | # |
| PROTECTOSEAL | # | # | # | 809 | # |

2A:20B:C, 2A:40B:C, 2A:60B:C, 3A:80B:C EXTINGUISHERS AND BRACKETS

| | | | | | |
|---|---|---|---|---|---|
| AMEREX | # | # | # | 810 | Extinguisher slipped up 1 inch, remained secure. |
| ANSUL | # | # | # | Mod. 809* | Extinguisher slipped up 3/4 inch, remained secure. |
| PEMALL | - | - | - | - | - |
| POTTER-ROEMER | # | # | # | 810 | # |
| PROTECTOSEAL | # | # | # | 810 | # |

# - Satisfactory performance.

*A longer adjustment bolt was added to the 809 Bracket to accommodate a larger diameter extinguisher.

(9) Sympathetic Detonation

(a) Objective

The sympathetic detonation test was conducted to determine if the fire extinguisher is capable of sustaining a shock wave, simulating an explosion in proximity to an aircraft without the extinguisher itself exploding or rupturing seals.

(b) Procedure

Extinguishers were pre-tested for proper operation and refilled to manufacturers' specifications. Prior to testing, extinguishers were checked for leaks with the GE Tracker® II Freon Detector.

One extinguisher of each representative size from each manufacturer was selected for this test. Six holes, 8 inches in diameter, 4 feet deep and placed 60 degrees apart in a 4-foot diameter circle, were dug at the Tyndall Air Force Base E.O.D. range (Figure 29). The 3/8-pound TNT charge was placed in the center of the 4-foot circle at a depth of 3 feet. Soil above the charge was tamped. Six fire extinguishers were placed inside the holes and loosely covered with the excavated soil. The charge was then detonated. After detonation, each extinguisher was closely examined for deformations and checked again for Halon leaks.

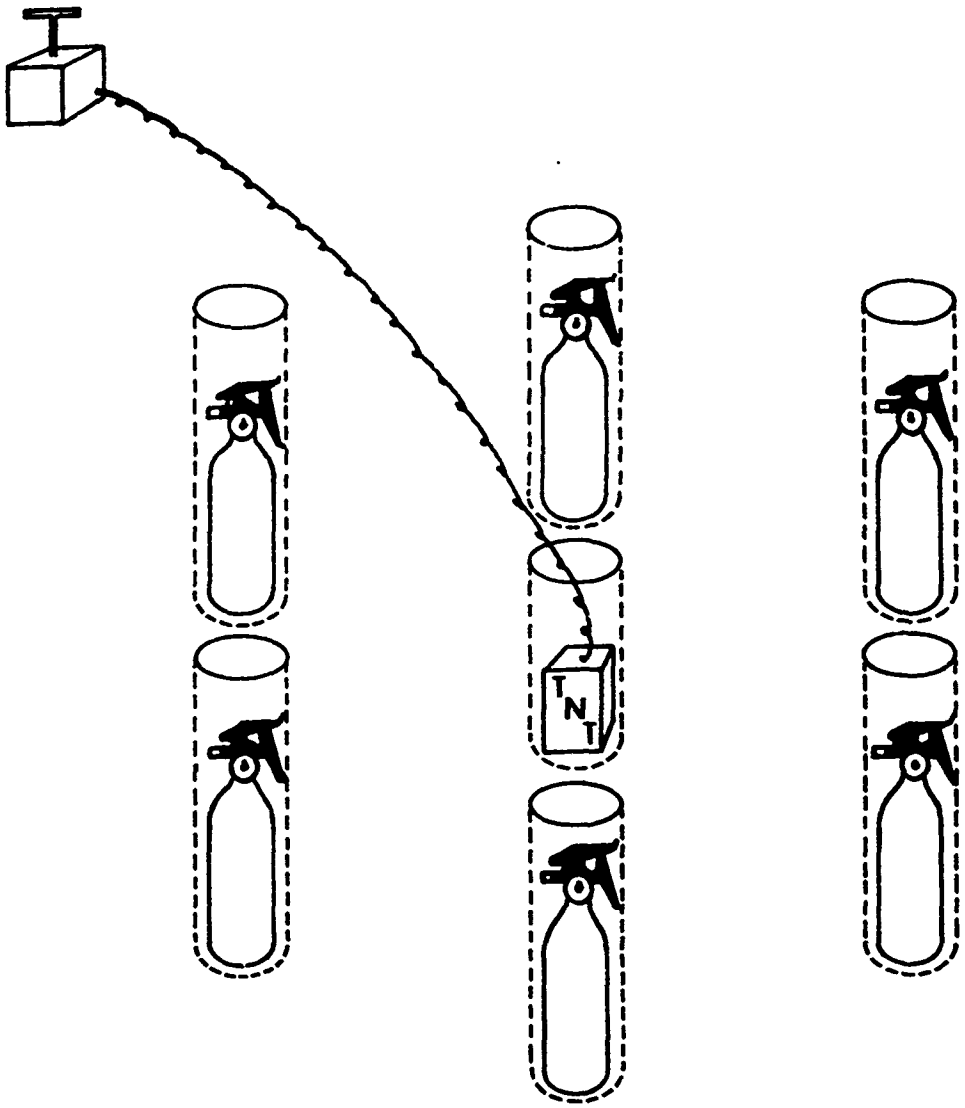



Figure 29. Sympathetic Detonation Test Arrangement

The test was conducted in damp, sandy soil with an approximate mean grain size of 0.25-0.20 mm. This estimate is based on previous sediment analysis conducted near this test site.

Criteria for this test required that the extinguisher's cylinders, valve/heads, pressure gauges, and seals remain intact after this shock.

(c) Results

After detonation, the extinguishers were tightly compacted in the soil, giving evidence that the shock wave reached the extinguishers. No adverse effects resulted from this test. Extinguishers retained their structural integrity and operational capability.

(10) Burst Pressure

(a) Objective

The objective of this test was to determine if the test extinguisher cylinder could withstand a pressure of 1000 psig.

(b) Procedure

Each extinguisher was hydrostatically tested using equipment manufactured by Hydrotest Products, Inc., Model HTP-1-14-R-#1338 (Figure 30). This equipment was Bureau of Explosives certified under Number BA 2779/272-16/Testing. Test cylinders were x-rayed after hydrostatic test to detect structural deformation resulting from over-pressurization.

Figure 30. Test Setup - Hydrostatic Testing

(c) Results

An attempt was made to hydrostatically test each cylinder to 1000 psig. In many cases this pressure could not be achieved because of the structure and design of the extinguisher cylinder necks. At higher pressures (from 575 psig to 1000 psig), some extinguishers leaked at the neck seal, thus preventing the buildup of pressures which could burst the cylinders. Results obtained are summarized in Tables 9 through 11, below.

TABLE 9. BURST PRESSURE

10B:C EXTINGUISHER

| | ITEM NUMBER | MAXIMUM ACHIEVABLE PRESSURE (psig) | RESULT |
|---|---|---|---|
| AMEREX | 1 | 800 | Excessive swelling/deformation. |
| | 2 | 700 | Excessive swelling/deformation. |
| ANSUL | 1 | 1000 | No change in cylinder structure. |
| | 2 | 1000 | No change in cylinder structure. |
| | 3 | 1000 | No change in cylinder structure. |
| | 4 | 1000 | No change in cylinder structure. |
| | 5 | 1000 | No change in cylinder structure. |
| GRAVINER | 1 | 750 | Swollen. |
| | 2 | 600 | Swollen. |
| | 3 | 700 | Slightly swollen. |
| PEMALL | 1 | 700 | Excessive swelling/deformation. |
| | 2 | 900 | Excessive swelling/deformation. |

TABLE 10. BURST PRESSURE

1A:10B:C EXTINGUISHER

| | ITEM NUMBER | MAXIMUM ACHIEVABLE PRESSURE (psig) | RESULT |
|---|---|---|---|
| AMEREX | 1 | 700 | Swollen. |
| | 2 | 600 | Slightly swollen. |
| ANSUL | 1 | 1000 | No change in cylinder structure. |
| | 2 | 1000 | No change in cylinder structure. |
| | 3 | 1000 | No change in cylinder structure. |
| | 4 | 1000 | No change in cylinder structure. |
| | 5 | 1000 | No change in cylinder structure. |
| GRAVINER | 1 | 700 | Slightly swollen. |
| PEMALL | 1 | 700 | Slightly swollen. |
| | 2 | 700 | Swollen. |
| PROTECTOSEAL | 1 | 700 | Swollen. |
| | 2 | 575 | No change in cylinder structure. |

TABLE 11. BURST PRESSURE

2A:20B:C, 2A:40B:C 2A:60B:C, 3A:80B:C EXTINGUISHERS

| | ITEM NUMBER | MAXIMUM ACHIEVABLE PRESSURE (psig) | RESULT |
|---|---|---|---|
| AMEREX (3A:80B:C) | 1 | 950 | None of these cylinders was structurally changed. |
| | 2 | 1000 | |
| | 3 | 900 | |
| | 4 | 900 | |
| | 5 | 1000 | |
| ANSUL (2A:40B:C) | 1 | 1000 | |
| | 2 | 1000 | |
| | 3 | 1000 | |
| | 4 | 1000 | |
| | 5 | 1000 | |
| GRAVINER (2A:20B:C) | 1 | 900 | |
| | 2 | 750 | |
| PEMALL (2A:40B:C) | 1 | 700 | |
| | 2 | 700 | |
| | 3 | 700 | |
| | 4 | 700 | |
| | 5 | 700 | |
| POTTER-ROEMER (2A:60B:C) | 1 | 1000 | |
| | 2 | 1000 | |
| | 3 | 1000 | |
| | 4 | 1000 | |
| | 5 | 1000 | |
| PROTECTOSEAL (2A:60B:C) | 1 | 850 | |
| | 2 | 850 | |
| | 3 | 850 | |
| | 4 | 850 | |
| | 5 | 850 | |

(d) Post Test X-Ray Examination

All extinguishers subjected to the hydrostatic test were subsequently x-rayed to detect structural changes. X-ray evaluations were performed by AFESC-DEMM. All extinguishers, despite some deformations, were determined to be structurally sound for operation at normal pressures. Due to safety considerations, however, excessively deformed cylinders were excluded from further testing.

(11) Static Loading

(a) Objective

This test was designed to determine the ability of the extinguisher bracket to hold the extinguisher against the static stresses that may be encountered during the service life of the bracket.

(b) Procedure

Static loads were applied in three directions on the extinguisher, with the bracket mounted to a solid surface by its normal mounting means. Loads were applied with a mechanical winch and measured with a spring scale (Hanson Model 8930).

Static loads were applied as follows:

200 pounds downward (Figure 31),

88 pounds upward (Figure 32), and

200 pounds outward (90 degrees to longitudinal axis, Figure 33) applied to the extinguisher midway between bracket strap and bottom of bracket.

Each load was applied, then removed before application of the next load.

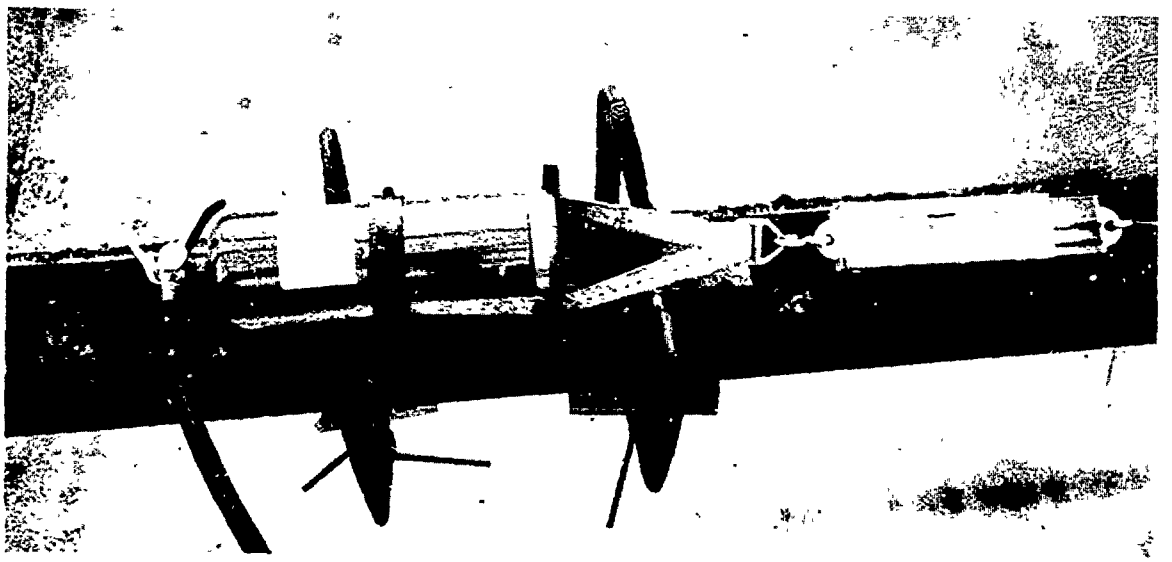


Figure 31. Static Load, 200 Pounds Downward

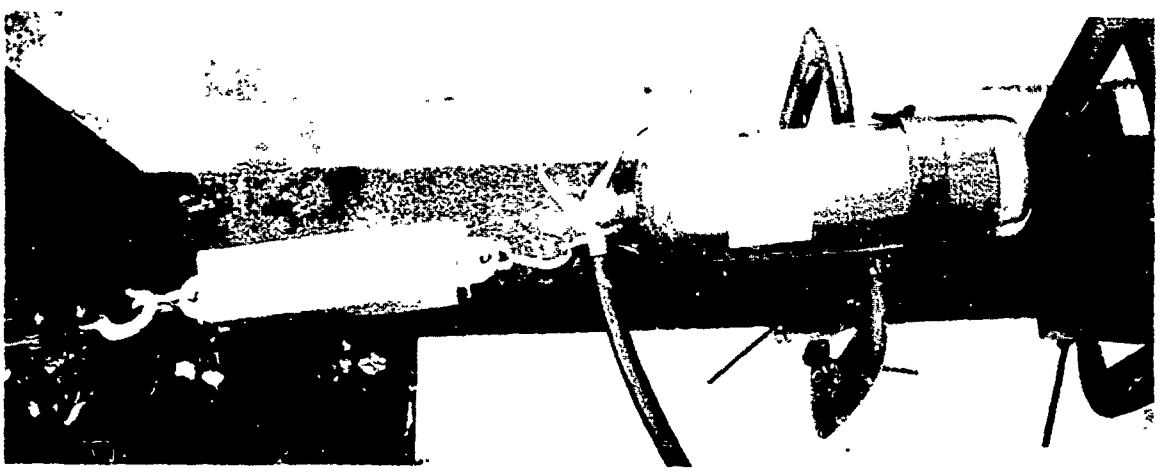


Figure 32. Static Load, 88 Pounds Upward

Figure 33. Static Load, 200 Pounds Outward

Test criteria required that the extinguisher remain securely installed in the extinguisher bracket, with no permanent deformation of the bracket resulting from the application of various static loads.

(c) Results

Results of static loading are shown in Table 12, below.

TABLE 12. STATIC LOADING

| BRACKET I.D. | DOWNWARD LOAD (lb) | RESULTS | UPWARD LOAD (lb) | RESULTS | OUTWARD LOAD (lb) | RESULTS |
|---|---|---|---|---|---|---|
| 810 | 200 | Remained secure. | 90 | Remained secure. | 200 | Remained secure. |
| 809 | 200 | Remained secure. | 88 | Remained secure. | 200 | Remained secure. |
| 818 | 200 | Remained secure. | 80 | Neck slipped up in fork. | 198 | Bottom of bottle pulled away from bracket. (Remained in bracket.) |
| 821 | 200 | Remained secure. | 95 | Remained secure. | 200 | Remained secure. |
| Lg. Penall | 200 | Remained secure. | 90 | Remained secure. | 205 | Remained secure. |
| Med. Penall | 200 | Remained secure. | 35 | Extinguisher pulled out. | 197 | Bottom of extinguisher pulled away from bracket. (Remained in bracket.) |
| Sm. Penall | 205 | Neck fork began to bend down bracket head. | 90 | Remained secure. | 205 | Remained secure. |

(12) Ballistic Penetration

(a) Objective

Extinguishers were tested to determine their capability to withstand the impact of a .50-caliber M-2 armor piercing projectile without shattering or fragmentation of the body.

(b) Procedure

Extinguisher was filled and pressurized to manufacturer's specifications, then placed against a sandfilled backstop inside a concrete reinforced bunker (Figure 34). A ground-mounted caliber .50 machine gun was positioned outside the bunker with the barrel projecting through an aperture in the steel door (Figure 35).

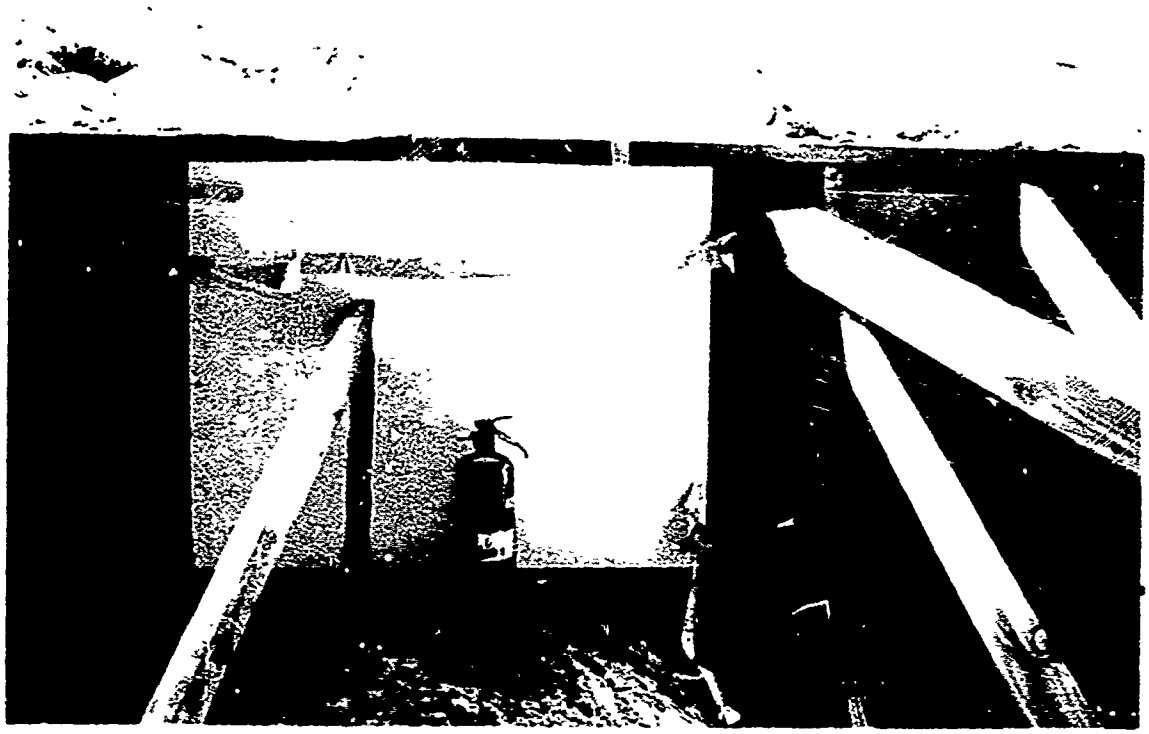


Figure 34. Extinguisher Inside a Concrete Reinforced Bunker

Figure 35. Machine Gun in Test Position

The distance between the muzzle of the machine gun and the extinguisher was 12 0 feet. Cardboard panels mounted behind and at the sides of the extinguisher were intended to provide indications of penetration by metal fragments resulting from possible shattering of the pressurized extinguisher cylinder. After test firing and zeroing, the aiming point was set in the center of the extinguisher body. The traverse and elevation mechanism of the machine gun were locked and the tripod legs weighted down to maintain the aiming point constant throughout the test. Ammunition used for the ballistic penetration test was M-2 armor piercing projectiles.

(c) Results

1 AMEREX

10B:C - Two extinguishers were tested. Projectile entry points were "clean." Both exhibited major deformations at the projectile exit points. The first had a gaping exit hole approximately three-quarters the length of the cylinder. The second extinguisher was split half the length of the cylinder with approximately one-third of the bottom separated. Neither extinguisher showed any evidence of fragmentation (Figure 36).

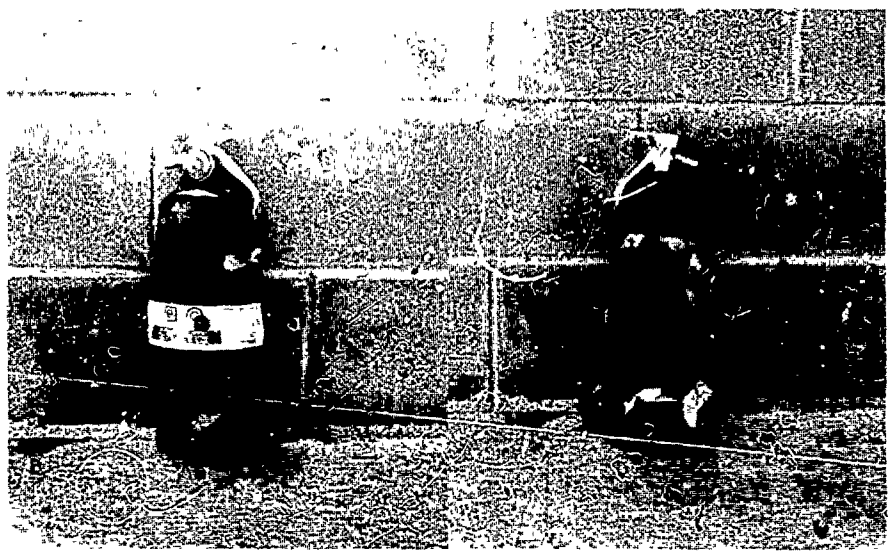


Figure 36. Amerex 10B:C/Projectile Entry and Exit

1A:10B:C - Two extinguishers of this size were also tested. One extinguisher was considered to be severely deformed. The projectile entry split the cylinder one-third of its length, and the exit point split the cylinder approximately half its length (Figure 37). The other extinguisher was not damaged to the same extent. The projectile entry point was a clean hole. The projectile exit split the cylinder approximately one-fifth its length (Figure 38). Neither extinguisher displayed evidence of fragmentation.

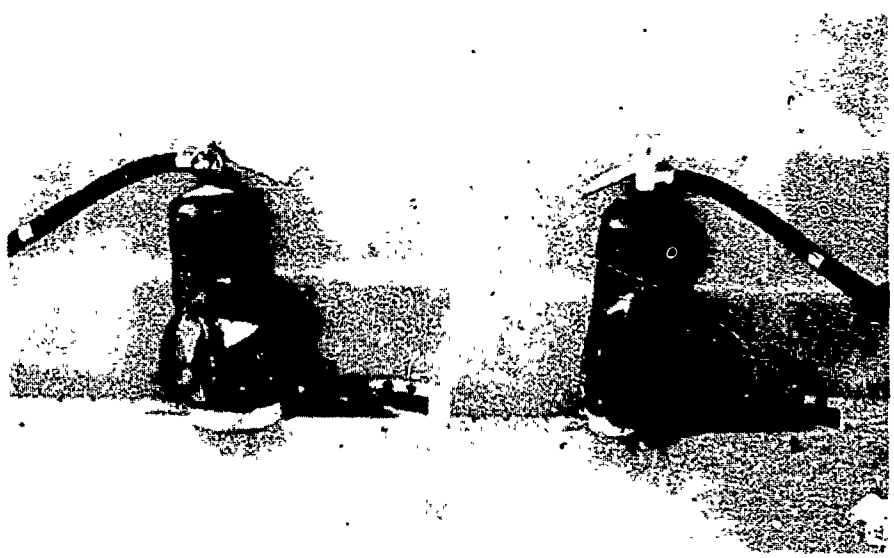


Figure 37. Amerex 1A:10B:C/Projectile Entry and Exit, Extinguisher 1

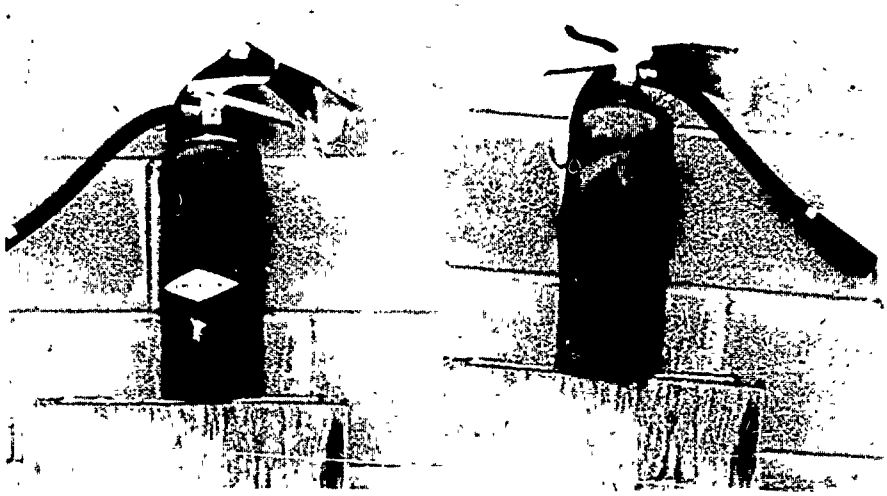


Figure 38. Amerex 1A:10B:C/Projectile Entry and Exit, Extinguisher 2

3A:80B:C - One extinguisher was tested; the projectile entry and exit points were clean holes with little or no deformation. There were two exit holes due to the projectile splitting (Figure 39).

Figure 39. Amerex 3A:80B:C/Projectile Entry and Exit

2 ANSUL

10B:C - Two extinguishers were tested. Both extinguishers had clean projectile entry points. The exit point for the first extinguisher was a gaping hole one-third of the cylinder length, with no evidence of fragmentation (Figure 40). The second extinguisher also displayed a gaping hole one-third the cylinder length with evidence of material loss or fragmentation (Figure 41).

Figure 40. Ansul 10B:C/Projectile Entry and Exit, Extinguisher 1

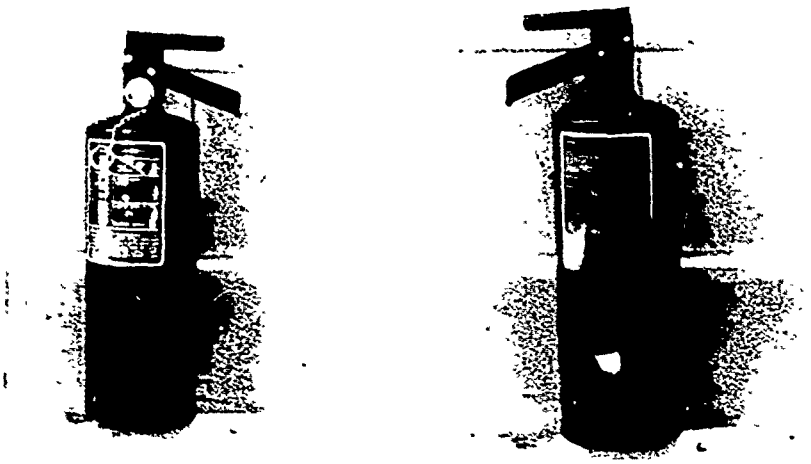


Figure 41. Ansul 10B:C/Projectile Entry and Exit, Extinguisher 2

1A:10B:C - Two extinguishers of this size were tested. As with the 10B:C extinguishers, the projectile entry points were clean holes. Both projectile exits split the cylinders top to bottom. One extinguisher was separated from its base, which became a loose fragment (Figure 42).

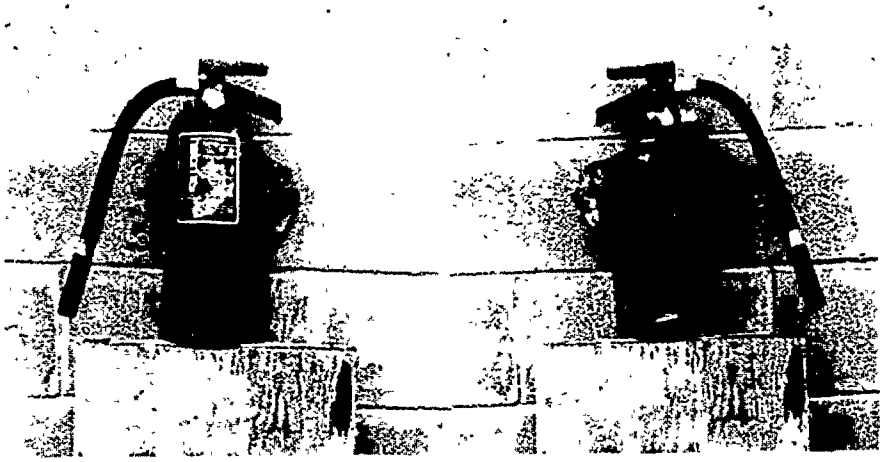


Figure 42. Ansul 1A:10B:C/Projectile Entry and Exit

2A:40B:C - Two 2A:40B:C Ansul extinguishers were tested. Both split at the projectile entrance and also split full length at the exit points. Both extinguishers were separated from their bases, which became loose fragments (Figures 43 and 44).

Figure 43. Ansul 2A:40B:C/Projectile Entry and Exit, Extinguisher 1

Figure 44. Ansul 2A:40B:C/Projectile Entry and Exit, Extinguisher 2

3 GRAVINER

10B:C, 1A:10B:C, 2A:40B:C - One extinguisher of each size was subjected to this test. Each exhibited little or no deformation with clean projectile entry and exit points (Figure 45).

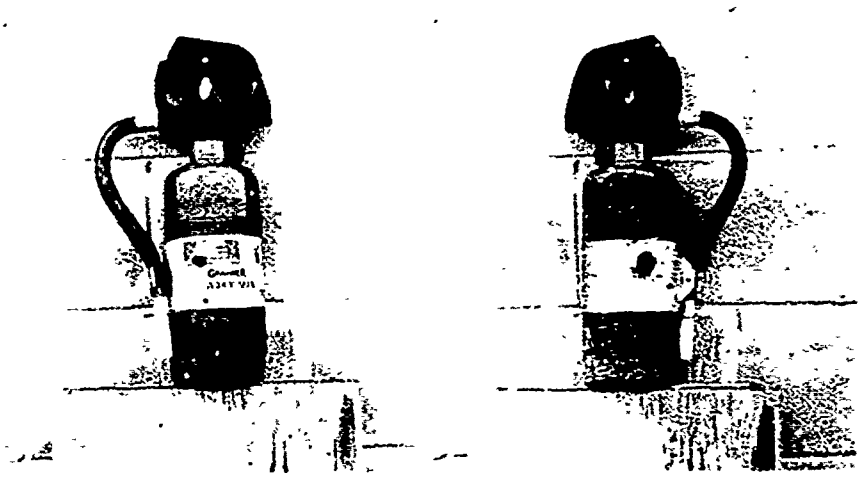


Figure 45. Graviner 10B:C, 1A:10B:C, 2A:40B:C/Projectile Entry and Exit

## 4 PEMALL

10B:C - Two Pemall 10B:C extinguishers were tested. The first extinguisher split slightly at projectile entry and split three-quarters the cylinder length and two-thirds around at the exit point. The other extinguisher exhibited a clean entry point with the exit point being a large gaping hole. Neither item displayed evidence of fragmentation (Figure 46).

Figure 46. Pemall 10B:C/Projectile Entry and Exit

1A:10B:C - Both Pemall 1A:10B:C extinguishers had clean projectile entry points. The first extinguisher had a clean split from the middle seam down to the bottom cap. The other extinguisher had a 4-inch split with the middle seam separated halfway around the cylinder. Neither item showed any evidence of fragmentation (Figure 47).

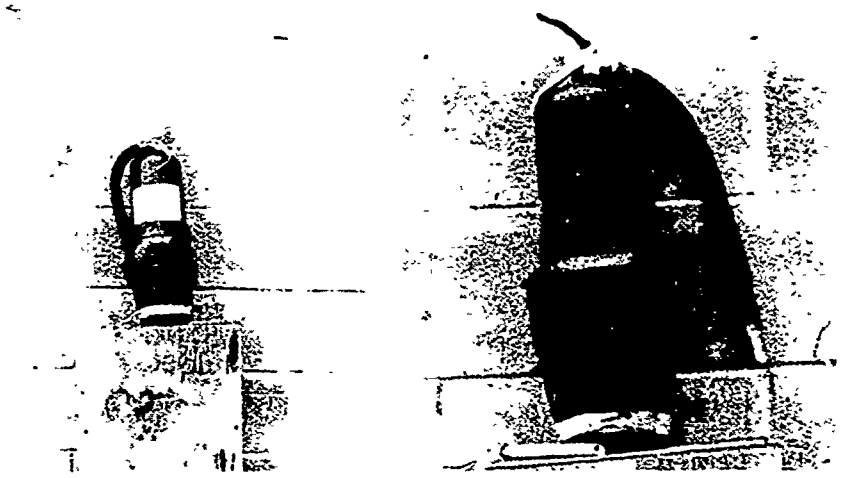


Figure 47. Pemall 1A:10B:C/Projectile Entry and Exit

2A:40B:C - Two Pemall extinguishers of this size were tested. Both had slight splits at the projectile entry points. The projectile exits split one extinguisher its entire length and the other three-quarters its length. There was no evidence of fragmentation from either extinguisher (Figure 48).

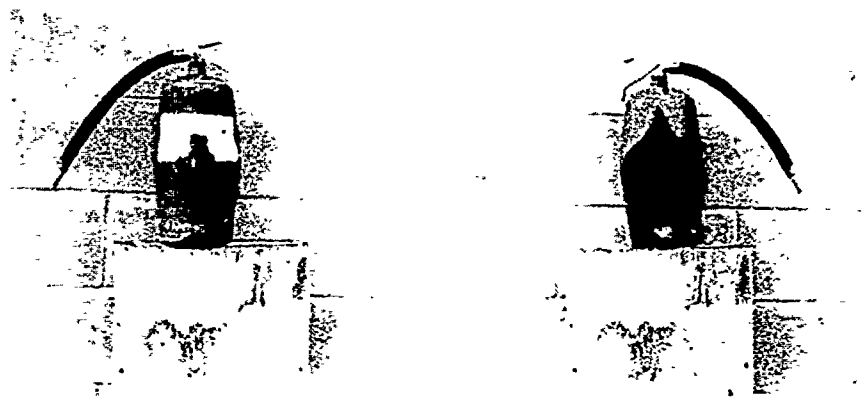


Figure 48. Pemall 2A:40B:C/Projectile Entry and Exit

5 POTTER-ROEMER

2A:60B:C - One bottle of this size was tested. There was some deformation where the projectile exited the cylinder; a gaping hole approximately one-fourth the length of the cylinder resulted. There was no evidence of fragmentation (Figure 49).

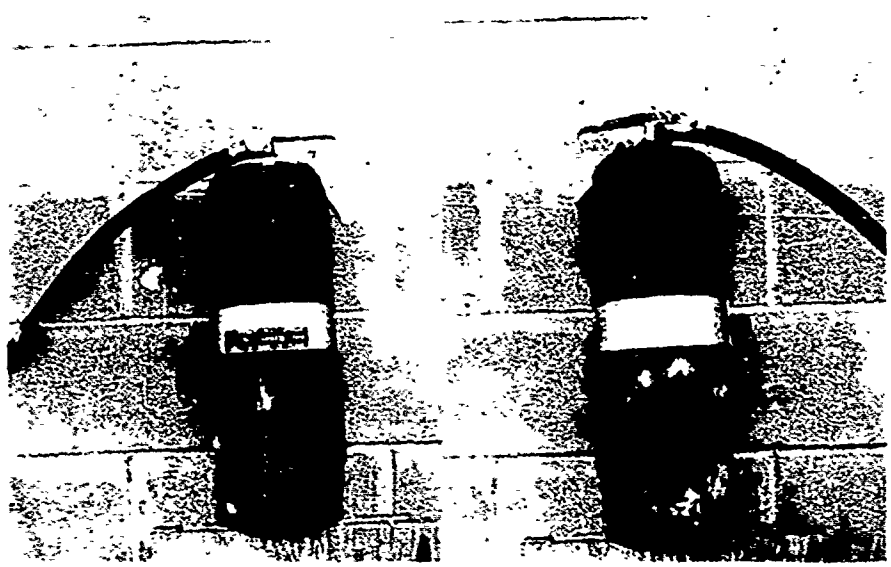


Figure 49. Potter-Roemer 2A:60B:C/Projectile Entry and Exit

## 6 PROTECTOSEAL

1A:10B:C - One extinguisher of this size was tested. The projectile entry and exit points were clean holes with little deformation and no fragmentation (Figure 50).

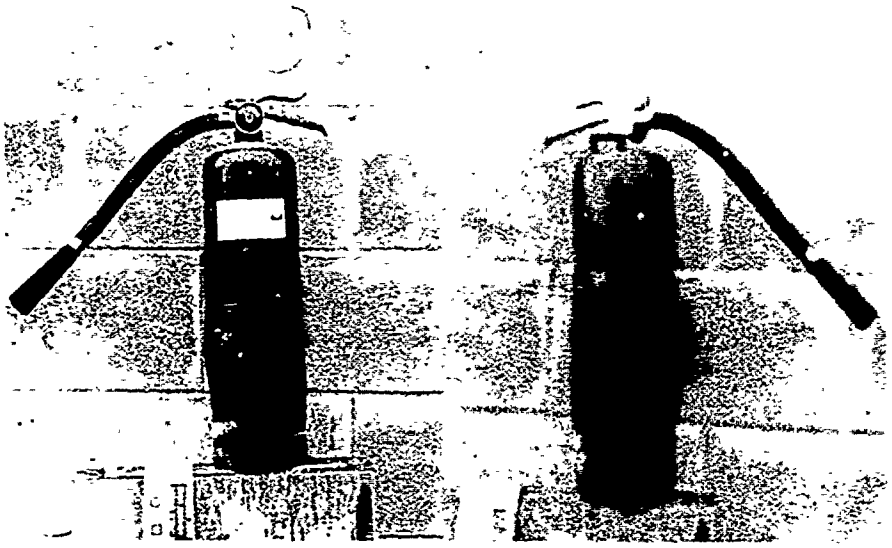


Figure 50. Protectoseal 1A:10B:C/Projectile Entry and Exit

2A:60B:C - One extinguisher was tested. The results were the same as for the 1A:10B:C. The entry and exit points were clean holes (Figure 51).

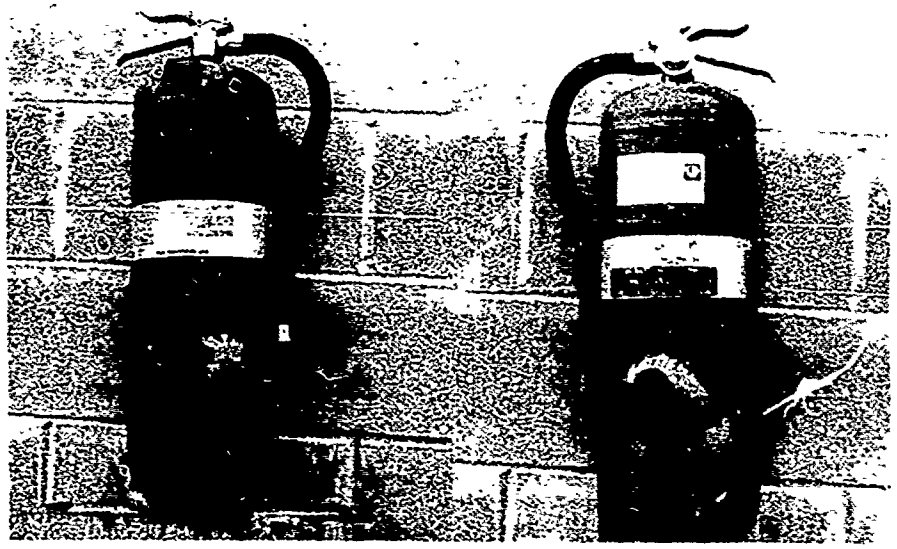


Figure 51. Protectoseal 2A:60B:C/Projectile Entry and Exit

# 7 Tabulated Results

Results of the ballistic penetration tests are tabulated by size (weight) and manufacturer of test extinguishers.

TABLE 13. BALLISTIC PENETRATION RESULTS

10B:C EXTINGUISHERS

| | ITEM NUMBER | PROJECTILE ENTRY | PROJECTILE EXIT | FRAGMENTATION |
|---|---|---|---|---|
| AMEREX | 1 | Clean hole. | Gaping hole 3/4 of cylinder length. | No |
| | 2 | Clean hole. | Split 1/2 cylinder length, 1/3 of bottom separated. | No |
| ANSUL | 1 | Clean hole. | Gaping hole 1/3 of cylinder length. | No |
| | 2 | Clean hole. | Gaping hole 1/3 of cylinder length. | Yes |
| GRAVINER | 1 | Clean hole. | Clean hole. | No |
| PEMALL | 1 | Split cylinder. | Split 3/4 of cylinder length and 2/3 around. | No |
| | 2 | Clean hole. | Large gaping hole. | No. |

1A:10B:C EXTINGUISHERS

| | ITEM NUMBER | PROJECTILE ENTRY | PROJECTILE EXIT | FRAGMENTATION |
|---|---|---|---|---|
| AMEREX | 1 | Split 1/3 of cylinder length. | Split 1/2 of cylinder length. | No |
| | 2 | Clean hole. | Split 1/5 of cylinder length. | No |
| ANSUL | 1 | Clean hole. | Split cylinder top to bottom. | No |
| | 2 | Clean hole. | Split cylinder top to bottom. Separated from the base. | Yes |
| GRAVINER | 1 | Clean hole | Clean hole. | No |
| PEMALL | 1 | Clean hole | Split from mid-seam down to base. | No |
| | 2 | Clean hole | 4-inch long split. Separated 1/2 way around cylinder. | No |
| PROTECTOSEAL | 1 | Clean hole | Clean hole. | No |

2A:20B:C, 2A:40B:C, 2A:60B:C, 3A:80B:C EXTINGUISHERS

| | ITEM NUMBER | PROJECTILE ENTRY | PROJECTILE EXIT | FRAGMENTATION |
|---|---|---|---|---|
| AMEREX (3A:80B:C) | 1 | Clean hole. | Two holes, projectile split. | No |
| ANSUL (2A:40B:C) | 1 | Split full length of cylinder. | Split full length of cylinder. Bottom separated. | Yes |
| | 2 | Split 2/3 of cylinder length. | Split full length of cylinder. Bottom separated. | Yes |
| GRAVINER | 1 | Clean hole. | Clean hole. | No |
| PEMALL | 1 | Slightly split. | Split top to bottom. | No |
| | 2 | Slightly split. | Split 3/4 length of cylinder. | No |
| POTTER-ROEMER | 1 | Clean hole. | Gaping hole 1/4 of cylinder length. | No |
| PROTECTOSEAL | 1 | Clean hole. | Clean hole. | No |

b. Evaluation of Extinguisher and Mounting Bracket Design Features

(1) Inspection of Extinguisher Components

Selected test items were disassembled after completion of the flightworthiness/crashworthiness tests to permit evaluation of the cylinder interior, siphon tube, and wear areas within the extinguisher's valve assembly. Table 14, below, lists the conditions found as a result of this evaluation.

TABLE 14. INSPECTION RESULTS

| EXT. SIZE | MANUFACTURER | SERIAL NUMBER | CONDITION |
|---|---|---|---|
| 10B:C | AMEREX | 844733 | Slight rust on cylinder's interior surface. |
| | | 844731 | Moderate rust on cylinder's interior surface. |
| | | 706098 | Rust in cylinder neck. |
| | ANSUL | 746484 | Rust around interior bottom seam of cylinder. Rust on siphon tube. |
| | | 864058 | Valve seal damaged; rust on interior surface of the cylinder and on the siphon tube. |
| | | 864100 | Rust in cylinder (especially at the bottom seam); rust also on siphon tube. |
| | | 746694 | Rust on interior surfaces of the cylinder and on the siphon tube. |
| | PEMALL | 150557 | No visible defects. |
| | | 150548 | Slight rust inside cylinder. |
| | | 150428 | Slight rust inside cylinder. |
| 1A:10B:C | AMEREX | 817267 | Rust on cylinder's interior surfaces. |
| | | 817270 | Rust on cylinder's interior surfaces. |
| | | 816107 | Slight rust on cylinder's interior surfaces; corrosion on the siphon tube; valve seal damaged. |
| | | 817290 | Rust on interior surfaces of cylinder; valve seal damaged. |
| | | 820139 | Slight rust in cylinder neck. |
| 1A:10B:C | ANSUL | 858743 | Slight rust on interior surfaces of cylinder; rust in cylinder neck and on siphon tube. |
| | | 858747 | Rust on interior surfaces of cylinder; rust is severe at the bottom seam and neck. There is also rust on the siphon tube. |
| | | 858744 | Rust on siphon tube and inside cylinder neck. |
| 1A:10B:C | PEMALL | 189122 | No defects. |
| | | 189126 | No defects. |
| 1A:10B:C | PROTECTOSEAL | 910175 | Slight rust on interior surfaces of cylinder. |
| | | 908455 | No defects. |
| 3A:80B:C | AMEREX | 927569 | Slight rust on interior surfaces of cylinder; corrosion on siphon tube; valve seal bad. |
| | | 927538 | Slight rust in cylinder neck. |
| | | 927572 | Interior of cylinder in good condition; valve seal bad. |
| 2A:40B:C | ANSUL | 742721 | Rust in cylinder neck and on siphon tube. |
| | | 742739 | Slight rust on interior surfaces of cylinder; rust on siphon tube. |
| | | 742725 | Rust in cylinder neck and on siphon tube. |
| 2A:20B:C | GRAVINER | 766097 | No problems (once operated extinguisher). |
| | | 766034 | No problems (once operated extinguisher). |

TABLE 14. INSPECTION RESULTS (Concluded)

| EXT. SIZE | MANUFACTURER | SERIAL NUMBER | CONDITION |
|---|---|---|---|
| 2A:40B:C | PEMALL | 776384 | No defects. |
| | | 776374 | No defects. |
| | | 776400 | No defects. |
| | | 776340 | Slight corrosion on valve shaft. |
| 2A:60B:C | POTTER-ROEMER | 788244 | Rust on interior surfaces of cylinder, especially in cylinder neck. |
| | | 788880 | Rust in cylinder neck; valve seal bad. |
| | | 788827 | Corrosion at different metal contacts in valve assembly; corrosion on and in siphon tube. |
| | | 788828 | Rust on interior surfaces of cylinder, especially along side seam. |
| 2A:60B:C | PROTECTOSEAL | 511232 | Slight rust inside cylinder; corrosion on siphon tube. |
| | | 511177 | Sticky substance and slight corrosion on siphon tube; interior of cylinder in good condition. |
| | | 600846 | Sticky substance and slight corrosion on siphon tube; valve seal bad. |
| | | 600804 | Sticky substance and slight corrosion on siphon tube. |

(2) Discharge Indicating Device (Pressure Gauge)

(a) Objective

Discharge indicating devices were observed throughout the course of the test program to ascertain gauge readings reflected accurately the extinguishers' current state (i.e., fully charged, discharged etc.).

(b) Procedure

Evaluation of discharge indicating devices began upon removal of the extinguishers from their shipping cartons prior to discharge of the factory-filled extinguishant. Gauge readings were compared with the pressure reading of the regulator of the nitrogen fill tank utilized in the recharging process that accompanied many of the crashworthiness/flightworthiness subtests.

(c) Results

All test extinguishers were found to be equipped with accurate pressure gauges. When maximum operating pressure was applied, all extinguishers' pressure gauges read in the green operating range.

Graviner extinguishers also contain a breakaway plastic disk located at the rear of the valve head. In the event the static seal is broken, this disk is punched out. The disk serves as a secondary discharge indicator.

(3) Safety Device

(a) Objective

Each extinguisher was evaluated for ease of removal and reinstallation of safety devices, which generally consisted of reusable metal or breakaway plastic pins. The purpose of the safety device is to prevent inadvertent operation during transit, storage, or handling, and during storage in its aircraft mounting bracket.

(b) Procedure

During operational testing of extinguishers following many of the crashworthiness/flightworthiness subtests, safety devices were removed and reinstalled when possible; criteria required single-hand operation. Reusable pins were to be attached to the operating head to prevent loss.

(c) Results

1 AMEREX - All Amerex extinguishers used metal pins as safety devices. These pins locked the top handles of the extinguishers in a position to prevent operation without removal of the pin. Only the 5A:80B:C (17 lb) had a retainer line to prevent loss of the pin after operation. Amerex safety devices were easily removed with a single hand for extinguisher operation.

2 ANSUL - All three sizes of Ansul extinguishers used metal safety pins attached to the valve head with a light chain to prevent loss. These devices were easily removed for extinguisher operation. Although the Ansul safety pin, when in place, did prevent inadvertent operation, it did not prevent the top lever from being flipped upwards. This characteristic was noticeable in the dynamic environmental tests (vibration and acceleration).

3 GRAVINER - The three sizes of Graviner extinguishers used a large metal safety pin with a spring loaded ball at the end to help secure the pin when in place. These pins are secured to the valve head with a bead chain to prevent loss. These pins fit somewhat tighter than the conventional metal pins used by other manufacturers. Pin removal is still an easy one-hand operation.

4 PEMALL - All Pemall extinguishers contained breakaway plastic safety devices. These plastic pins were removed by stiff pressure on the valve lever. This pressure can be obtained with a single hand. This safety device can also be broken inadvertently by dropping or other accidental application of sufficient pressure to the actuating lever. After recharging, a new pin must be installed.

5 POTTER-ROEMER - The Potter-Roemer 2A:60B:C extinguisher used a conventional metal safety pin attached to the valve head with a monofilament nylon strap to prevent loss. Removal is an easy one-hand operation.

6 PROTECTOSEAL - The Protectoseal safety devices are conventional metal pins. The pin of the 1A:10B:C is not attached to prevent loss. The 2A:60B:C has its pin attached to the valve head with a monofilament nylon strap. Removal is an easy one-hand operation for both sizes.

(4) Extinguisher Markings

This evaluation focused upon the markings (labels, operating and recharging instructions) found on the Halon 1211 extinguishers. Detailed descriptions of markings are provided in Tables 15 through 17, below.

TABLE 15. 10B:C NAMEPLATE DATA

| Manufacturer (Size) | Label Material | Label Attachment | Method Of Operation | Identification Of Contents |
|---|---|---|---|---|
| Amerex 10B:C | Vinyl | Adhesive | White 1/8-inch letters on green background, located on front of cylinder. | Green 3/32-inch letters on white background, located on front of cylinder; indicates amount of agent. Also, smal. vinyl label on neck indicating type of agent. |
| Ansul 10B:C | Vinyl | Adhesive | White 1/8-inch letters on black background. Also, 3 pictures 3/4-inch square, white on black. | White 5/8-inch letters on black background, type of agent only -- located on front of cylinder. Amount of agent is located on the back in 1/16-inch letters. |
| Graviner 10B:C | Aluminum | Adhesive and nut and bolt. | Silver 1/8-inch letters on red background, also one picture 1-1/4 inch square located on front of cylinder. | 1/16-inch letters on side of cylinder -- amount of agent is the same size and in the same location. |
| Pemall 10B:C | Vinyl | Adhesive | 1/8-inch letters, black on white, located on front of cylinder. | 3/32-inch letters located on front of cylinder, 1/16-inch letters under recharge equals amount of agent. |

| Manufacturer (Size) | Total Weight | Serial Numbers | U.L. Classification And Rating | Warning |
|---|---|---|---|---|
| Amerex 10B:C | Green 1/8-inch letters on white located on side of cylinder. | Printed 1/8-inch letters, black on white located on side of cylinder. | 11/16-inch symbol and letter, located on front label. Rating is 3/16-inch letters, green on white, located on side of cylinder. | 1/16-inch fine print located on front of cylinder (exposure); 1/16-inch letters on side of cylinder (operating distance). |
| Ansul 10B:C | White 1/16-inch letters on black, located on back label. | White on black 3/16-inch letters located on back label. | Symbols and letter code 5/32-inch on front label, white on black. Rating on back label, 1/32-inch letters, white on black. | 1/8-inch letters on front label, white on black (exposure and operating distance). |
| Graviner 10B:C | Bold 1/16-inch letters located on back of label. | 1/16-inch letters embossed in aluminum label. | 5/16-inch letters and symbols, color coded. Also spelled out in 1/16-inch letters above each symbol, located on front of cylinder. | Bold 1..6-inch letters on side of cylinder (exposure). |
| Pemall 10B:C | 1/16-inch letters on side of cylinder. | 3/16-inch letters on side of cylinder, black on blue. | Symbols, letters are spelled out on front of cylinder. Rating is on the side of the cylinder in 1/16-inch letters. | 1/16-inch letters on cylinder side (exposure). |

TABLE 16. 1A:10B:C NAMEPLATE DATA

| Manufacturer (Size) | Label Material | Label Attachment | Method Of Operation | Identification Of Contents |
|---|---|---|---|---|
| Amerex 1A:10B:C | Aluminum | Crimped | 1/2-inch letters, silver on green, located on front of cylinder | Bold 1/8-inch letters on front of cylinder, also on a small vinyl label near neck. Amount of agent is on front in 1/8-inch letters. |
| Ansul 1A:10B:C | Vinyl | Adhesive | 1/8-inch white on black letters, also 3/4-inch pictoral - 3 pictures. | 5/8-inch white on black letters. The amount of agent is written in small 1/16-inch letters on back label. |
| Graviner 1A:10B:C | Aluminum | Nut and bolt plus adhesive. | 1/8-inch letters, silver on red, one picture - 1-1/4 inch square. | 1/16-inch letters on side of cylinder. Amount of agent is also 1/16-inch letters on the cylinder side. |
| Pemall 1A:10B:C | Vinyl | Adhesive | 3/32-inch letters, black on white, located on front of cylinder. | 1/8-inch letters on front of cylinder. Amount of agent in 1/16-inch letters under recharge instructions. |
| Protectoseal 1A:10B:C | -- All the same as Amerex 1A:10B:C. -- | | | |

| Manufacturer (Size) | Total Weight | Serial Numbers | U.L. Classification And Rating | Warnin |
|---|---|---|---|---|
| Amerex 1A:10B:C | Bold 3/32-inch letters on back of cylinder. | 1/8-inch embossed on side of extinguisher. | 1/2-inch letters and symbols on extinguisher front. Rating is on the extinguisher side in 1/16-inch letters. | Bold 1/16-inch letters on the extinguisher's side (operating distance and exposure). |
| Ansul 1A:10B:C | 1/16-inch letters on back label. | White on black 3/16-inch letters on back label. | 5/32-inch symbols and letters on front label. Rating is on back label in 1/32-inch letters. | 1/8-inch letters on front label (exposure and operating distance). |
| Graviner 1A:10B:C | Bold 1/16-inch letters on back of cylinder. | 1/16-inch embossed in aluminum label. | 5/16-inch letters and symbols, color coded, also spelled out in 1/16-inch letters above each symbol. Located on front of cylinder. | Bold 1/16-inch letters on side of extinguisher (exposure). |
| Pemall 1A:10B:C | 1/16-inch letters on cylinder side. | 1/8-inch letters on cylinder side. | Symbols, letters and written out, on front of cylinder. | 3/32-inch letters on side of cylinder (exposure). |
| Protectoseal 1A:10B:C | -- All the same as Amerex 1A:10B:C. -- | | | |

TABLE 17. 2A:20B:C, 2A:40B:C, 2A:60B:C AND 3A:80B:C NAMEPLATE DATA

| Manufacturer (Size) | Label Material | Label Attachment | Method Of Operation | Identification Of Contents |
|---|---|---|---|---|
| Amerex 3A:80B.C | Aluminum | Crimped | 1/2-inch letters, silver on green, located on front of cylinder. | Bold 1/8-inch letters on front of cylinder, also on a small vinyl label near neck. Amount of agent is on front in 1/8-inch letters. |
| Ansul 2A:40B:C | Vinyl | Adhesive | 1/4-inch letters, pictoral. Three 1-inch pictures on front of cylinder. | 13/16-inch letters on front. Amount of agent is on back label in 1/16-inch letters. |
| Graviner 2A:20B:C | Aluminum | Nut and bolt plus adhesive. | 1/8-inch silver letters on red background. One picture, 1-1/4 inch square. All on front of cylinder. | 1/16-inch letters on side of cylinder. Amount of agent is in the same location, 1/16-inch letters. |
| Pemall 2A:40B:C | Vinyl | Adhesive | 1/4-inch letters, black on white. Located on front of extinguisher. | 1/8-inch letters on front of cylinder. Amount of agent in on back of cylinder in 1/16-inch letters. |
| Potter-Roemer 2A:60B:C | -- Same as Amerex 3A:80B:C -- | | | |
| Protectoseal 2A:60B:C | -- Same as Amerex 3A:80B:C -- | | | |

| Manufacturer (Size) | Total Weight | Serial Numbers | U.L. Classification And Rating | Warning |
|---|---|---|---|---|
| Amerex 3A:80B:C | Bold 3/32-inch letters located on back of cylinder. | 1/8-inch letters embossed on side of extinguisher. | 1/2-inch letters and symbols on front of extinguisher. Rating is on the cylinder side in 1/16-inch letters. | Bold 1/16-inch letters on side of extinguisher (operating distance and exposure). |
| Ansul 2A:40B:C | On back label in 1/16-inch letters. | 3/16-inch letters on back label. | Letters and symbols on front of extinguisher in 3/16-inch letters. Rating in 1/16-inch letters on back label. | 1/8-inch letters on front of cylinder (exposure and distance). |
| Graviner 2A:40B:C | Bold 1/16-inch letters located on back of cylinder. | 3/16-inch letters embossed on side of cylinder. | 5/16-inch letters and symbols, color coded. Also spelled out in 1/16-inch letters above each symbol. All located on front of cylinder. | Bold 1/16-inch letters on on cylinder side (exposure). |
| Pemall 2A:40B:C | 1/16-inch letters on side of cylinder under recharge instructions. | 3/16-inch letters on side of cylinder, black on blue. | Symbols, letters and spelled out, on front of cylinder. Rating is on the side of the cylinder in 1/16-inch letters. | 3/16-inch letters on front of cylinder (exposure). |
| Potter-Roemer 2A:60B:C | -- Same as Amerex 3A:80B:C -- | | | |
| Protectoseal 2A:60B:C | -- Same as Amerex 3A:80B:C -- | | | |

c. Summary of Test Results

(1) Leakage

The initial test of factory-charged extinguishers detected no measurable leakage. However, leakage did occur during subsequent tests when the test articles were subjected to crashworthiness/flightworthiness examination.

(2) Method of Operation and Recharging

After the initial discharge of the factory-charged extinguisher, most test items were able to sustain 23 repetitive charges and discharges without any detectable loss in operational or recharging capability. All three sizes of Graviner-manufactured extinguishers failed to reseal after partial discharge; recharging the Graviner line of extinguishers requires specialized equipment which was not available during the course of the test program. As a consequence, Graviner products participated in the program to the extent that only factory-fresh extinguishers could be exposed to individual subtests. A poor thread match between the valve head and the discharge hose fitting of the Pemall 10-pound and 14-pound (1A:10B:C and 2A:40B:C) extinguishers grew progressively worse as the number of recharges increased. Reinstallation of the hose after recharging proved difficult and the poor thread connection allowed a portion of the propellant to escape at the extinguisher head upon discharge. A single Amerex extinguisher (10B:C) developed excessively worn threads and could not be recharged.

(3) High Temperature

Few extinguishers developed problems as a result of the high temperature test. The Graviner extinguishers, as previously noted, experienced difficulty in resealing after a partial discharge. One 2A:20B:C Graviner discharged its agent at the top and rear of the valve head. Two Ansul extinguishers (one 1A:10B:C and one 2A:40B:C) developed static seal leaks that allowed the gradual escape of their contents.

(4) Low Temperature Versus Altitude, Explosive Decompression and Temperature Shock

The deleterious effects brought on by the combination of extreme temperature variation, low pressure, and explosive decompression were felt by most test articles. A common affliction was the loss in varying degrees of the nitrogen pressure. The entire line of Amerex-manufactured test articles (which included Potter-Roemer and Protectoseal), with the exception of the Amerex 10B:C (5 lb), experienced an almost uniform loss of nitrogen pressure. The Ansul 2A:40B:C (14 lb) met the same difficulties. The other Ansul sizes (10B:C and 1A:10B:C) and all Pemall extinguishers achieved better than average post-test performance results. Graviner extinguishers showed no effects from this test

(5) High Temperature Versus Altitude

Exposure to high temperature and altitude generally produced no adverse effects. Two extinguishers (an Ansul 2A:40B:C and a Protectoseal 2A:60B:C) developed a leak in the static seal. The remaining test articles performed satisfactorily during post-test operational checks.

(6) Vibration

Exposure to sustained vibrations at the level of 5.8 g had no deleterious effects on the extinguishers, although during post-test discharge some liquid emissions were observed. In general, the effectiveness of the extinguishers' discharges remained unimpaired. The Graviner 2A:20B:C and the Amerex 3A:80B:C did not display the liquid emission at discharge. Two Potter-Roemer 2A:60B:C extinguishers developed static seal leaks as a result of the test.

(7) Salt Fog

Most of the extinguishers subjected to the salt fog exposure experienced only minor difficulties. Extinguishers utilizing cylinders with swaged seams (Graviner 10B:C, 1A:10B:C, 2A:20B:C, Pemall 1A:10B:C and Protectoseal 1A:10B:C) are most susceptible to exterior cylinder rust. Pemall 1A:10B:C and 2A:40B:C extinguishers utilize dissimiliar metals in the hose connections and fittings (aluminum fittings versus brass connecting sleeves). Such a design results in excessive corrosion of aluminum fittings when exposed to salt atmosphere. The most pronounced effect of exposure to a salt-laden atmosphere was experienced by Graviner extinguishers. Featuring unsealed actuating mechanisms, these extinguishers are highly susceptible to corrosive atmospheres. During the course of the 200-hour exposure, Graviner test items developed corrosion on valve springs and salt buildup inside the valve actuating assemblies; Graviner safety pins were removed with difficulty.

(8) Acceleration

(a) Operational Test

Most test items were able to be operated (discharged) while under the stress of a 9.0 g exposure. At that g-level, three of the larger (17-pound) extinguishers (Amerex 3A:80B:C, Potter-Roemer 2A:60B:C, and Protectoseal 2A:60B:C) discharged their nitrogen content without expelling the Halon extinguishant. When acceleration was reduced to 5.2 g, these extinguishers performed properly.

(b) Structural Test

No adverse reaction occurred as a result of the series of structural tests.

(9) Sympathetic Detonation

All extinguishers subjected to this test showed no adverse effects. No physical damage resulted and post-test operation checks were satisfactory. There was no post-exposure leakage in any test item.

(10) Burst Pressure

The only test articles capable of withstanding over-pressurization to 1000 psig were the Ansul products (all sizes). The other test articles were unable to achieve this pressure for a variety of reasons, such as ductility of the metals used, structure and design of the cylinder, the cylinder neck, and sealing arrangements.

(11) Static Loading

Static loading exercised only the mounting brackets and had no effect on the test extinguishers.

(12) Ballistic Penetration

Fragmentation of the extinguisher body as a result of ballistic penetration by an armor-piercing projectile was experienced by only one manufacturers' product -- the Ansul test articles. Although deformed at the point of the projectile's exit, all other test articles were devoid of fragmentary disintegration.

(13) Summary of Test Results of Mounting Brackets

Candidate brackets were evaluated in four tests: salt fog, acceleration, vibration and static loading.

(a) Salt Fog

Most extinguisher brackets subjected to the salt fog test corroded excessively. Amerex Bracket 818 and the Small Pemall, designed for the 10B:C Amerex and Pemall extinguishers, respectively, were the most resistant to the salt atmosphere. Due to late acquisition, the Model 821 bracket was not subjected to this test. It is expected to perform similarly to the Model 818 (material and protective coating are identical). Brackets 809, 810, Medium Pemall, and Large Pemall all suffered heavy corrosion and separation of paint from the metal.

(b) Acceleration - Structural Test

Fifty percent of the brackets subjected to the series of acceleration tests performed satisfactorily. Brackets 809, 810, and 821 performed adequately in all directions of acceleration. The Large and Small Pemall brackets suffered minor deformations but managed to hold the extinguisher securely in place. Model 818 experienced a failure during the outward acceleration and a minor deformation during the downward acceleration.

(c) Vibration

Few of the brackets subjected to this test performed satisfactorily. Brackets 809 and 810 lost their retaining capability when the two back braces collapsed. A simple modification, rubber spacers placed behind the braces, alleviated the problem. These brackets then achieved 6 hours exposure. The Small and Medium Pemall and the Model 818 brackets were unable to hold the extinguisher in place for the planned period of vibratory exposure.

(d) Static Loading

Most test items experienced no difficulties when subjected to a series of static loads. The Small Pemall and the Model 818 brackets developed minor deformations of the neck yokes; the extinguishers remained secure. The Medium Pemall failed to secure the 1A:10B:C extinguisher during upward static loading. The extinguisher slipped out with a loading of 35 pounds. The remaining brackets performed satisfactorily.

## SECTION V

## CONCLUSIONS

An examination of the results of the technical test and evaluation program leads to the following conclusions:

1. The program has achieved the original goal of identifying commercially available, off-the-shelf Halon 1211 hand-portable fire extinguishers which meet flightworthiness/crashworthiness requirements for use as first-aid fire extinguishers in aircraft cabin applications.

2. The state of the art in Halon 1211 fire extinguishers indicates that it is feasible to manufacture units which could substantially conform to military specifications for use onboard aircraft.

3. The military specifications developed under this program (Draft Purchase Description, Appendix C) reflect the findings of the test and evaluation effort, thus insuring that a standard design will satisfy Air Force reliability and maintainability requirements beyond those specified by NFPA and Under writers Laboratories for commercial Halon 1211 units.

## SECTON VI

## RECOMMENDATIONS

The following recommendations are made:

1. Designate Halon 1211 hand-portable fire extinguishers (5, 10, and 17 pounds) as standard Air Force extinguishers, replacing the Halon 2011 (A-20) units, for aircraft cabin applications.

2. Insure the draft procurement specifications presented in Appendix C are finalized by Air Logistics Command (WR-ALC/MMTR).

3. Submit draft specifications to affected air craft systems managers in order to permit verification of preliminary structural installations.

4. Use the in-house capability developed by AFESC/RDCF for the T&E program to perform first article testing in order to reduce overall program costs and to expedite procurement of new extinguishers.

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# APPENDIX A

## MANUFACTURERS' DATA

Amerex Corporation
Post Office Box 81
Trussville, Alabama 35173
(205) 655-3271

Ansul Company
1 Stanton Street
Marinette, Wisconsin 54153
(715) 735-7411

Graviner, Inc.
1121 Bristol Road
Mountainside, New Jersey 07092
(201) 654-6800

Pemall Fire Extinguisher Corporation
39A Myrtle Street
Cranford, New Jersey 07016
(201) 276-0211

Potter-Roemer
2650 Leonis Boulevard
Los Angeles, California 90058
(213) 589-7301

Protectoseal Company
225 West Foster Avenue
Bensenville, Illinois 60106
(312) 595-0800

## APPENDIX B

## SCORING TECHNIQUES

METHOD OF OPERATION AND RECHARGE, WEIGHTING INDEX: 10

| Score | |
|---|---|
| 10 | Operation satisfactory. NFPA Standard met for time and distance. Resealed properly after partial discharge. No operational problems. No problems encountered during recharging. |
| 7 | NFPA Standard satisfied for time and distance. Resealed properly after partial discharge. Slight operational problems (stiff operation, leakage at the hose gasket). Refill, slight problem (hose threads tight, etc.). |
| 4 | NFPA Standard satisfied for time and distance. Slow to reseal after partial discharge. Difficult to refill. |
| 1 | Does not meet NFPA Standard for distance and time. Does not reseal after partial discharge. |
| 0 | Cannot refill. Agent leak before or after test. |

HIGH TEMPERATURE, WEIGHTING INDEX: 10

| Score | |
|---|---|
| 10 | Discharged properly at 120°F. No leak during or after exposure to heat. Resealed promptly after partial discharge. Label - clear and intact. Hose and nozzle intact. Finish (paint) - no flaking or cracking. |
| 7 | Discharged properly at 120°F. No leak during or after exposure to heat. Hose and nozzle intact. Finish - intact, no flaking or cracking. Slow reseal after partial discharge. Label - slight deformation. |
| 4 | No leak during or after exposure to heat. Hose and nozzle intact. Intermittent discharge at 120°F. No reseal after partial discharge. Label loose or unreadable. Finish - cracking or flaking slightly. |
| 1 | Problems in critical areas: Discharge not adequate. Hose and nozzle deformed. Label separated or unreadable. Paint cracking or flaking (excessive). |
| 0 | Leak during or after heat exposure. |

LOW TEMPERATURE VERSUS ALTITUDE AND EXPLOSIVE DECOMPRESSION, WEIGHTING INDEX: 10

| Score | |
|---|---|
| 10 | Pressure in green. Throw distance met NPFA Standards. No leakage during or after exposure. Hose and nozzle intact. Labels intact and readable. |
| 7 | Met NFPA Standards for distance and time. Pressure in green. Hose and nozzle intact. No leakage during or after exposure. Slight intermittent discharge. Slight label deformation. |
| 4 | Met NFPA Standards for distance and time. No leakage after exposure. Pressure drop (stream still effective). Label deformation severe but readable. Intermittent discharge. Hose or nozzle slightly deformed. |
| 1 | Does not meet NFPA Standards requirements for distance and time. Extremely low pressure (liquid discharge). Hose or nozzle deformed excessively or cracked. Label deformed (not legible). |
| 0 | Leak after exposure. |

HIGH TEMPERATURE VERSUS ALTITUDE, WEIGHTING INDEX: 10

| Score | |
|---|---|
| 10 | Met NFPA Standards for discharge time and distance. Excellent stream condition. Pressure in green. No leaks. |
| 7 | Met NFPA Standard for discharge time and distance. No leaks. Good stream characteristic (slightly intermittent). Pressure slightly off. |
| 4 | Met NFPA Standard for time and distance. No leaks. Intermittent discharge. Pressure down, below green. |
| 1 | Does not meet NFPA Standard for time and distance. Liquid discharge. |
| 0 | Leak after exposure. |

VIBRATION, EXTINGUISHERS, WEIGHTING INDEX: 10

| Score | |
|---|---|
| 10 | Discharge time meets NFPA Standards. Stream characteristic excellent. No leakage. |

| | |
|---|---|
| 7 | Discharge time meets NFPA Standards. Good stream characteristic (slightly intermittent, liquid emission during discharge). No leakage. |
| 4 | Discharge time meets NFPA Standards. Weak intermittent stream. No leakage. |
| 1 | Discharge time does not meet NFPA Standards. Poor stream (liquid). |
| 0 | Leakage. |

SALT FOG, EXTINGUISHERS, WEIGHTING INDEX: 8

| Score | |
|---|---|
| 10 | No body rust, no corrosion on valve or hose fittings, labels fully intact. Operation satisfactory. |
| 7 | Slight body rust (wear areas or paint chips). Slight rust or corrosion on valve body and hose fittings. Operation satisfactory. |
| 4 | Body rust at critical areas (seams). Valve rust or corrosion in vital areas (springs or safety pin). Operation satisfactory. |
| 1 | Excessive rust or corrosion that adversely affects operation or shows the need for excessive maintenance. |

ACCELERATION, OPERATIONAL, EXTINGUISHERS, WEIGHTING INDEX: 5

| Score | |
|---|---|
| 10 | Operation is satisfactory at minimum g-level. |
| 1 | Unsatisfactory operation at minimum g-level. |

All extinguishers survived the structural acceleration tests satisfactorily. Since all extinguishers performed equally for this test no score will be applied.

BURST PRESSURE, HYDROSTATIC TESTING, WEIGHTING INDEX: 5

| Score | |
|---|---|
| 10 | No deficiencies (swelling or paint cracking). |
| 7 | Slightly swollen. |
| 4 | Swollen excessively. |
| 0 | Burst. |

For this test there is a 0.1 weighting factor for each 100 psig achieved in the test.

Example: Bottle #1 reached 1000 psig with no problems.
WF = 1.0 (for 1000 psig)
Score = 10 Final Score WF x Score =
1.0 x 10 = 10 x WI

Bottle #2 reached 900 psig (excessively swollen).
WF = 0.9 0.9 x 4 =
Score = 4 Final Score = 3.6 x WI

BALLISTIC PENETRATION, WEIGHTING INDEX: 10

| Score | |
|---|---|
| 10 | Body intact. Projectile entry and exit hole only. |
| 7 | Slight deformation. No spalling. |
| 4 | Major deformation. No spalling. |
| 0 | Fragmented. Shattered body. |

SALT FOG, BRACKETS, WEIGHTING INDEX: 5

| Score | |
|---|---|
| 10 | No rust or corrosion. Operation satisfactory. |
| 7 | Slight rust in non-critical areas. Operation satisfactory. |
| 4 | Heavy rust and corrosion. Paint removed. Operation satisfactory. |
| 1 | Heavy rust and corrosion. Operation difficult. |
| 0 | Excessive corrosion - inoperable. |

ACCELERATION, BRACKETS, WEIGHTING INDEX: 10

| Score | |
|---|---|
| 10 | Bracket securely held the extinguishers with no loosening or deformation. |
| 7 | Bracket held extinguisher with a slight loosening of the strap. No deformation. |
| 4 | Bracket held extinguisher with some loosening caused by deformation. |
| 0 | Bracket failed to hold extinguisher. |

VIBRATION, BRACKETS, WEIGHTING INDEX: 10

| Score | |
|---|---|
| 10 | Bracket securely held extinguisher with no loosening or deformation. |
| 7 | Bracket securely held extinguisher with a slight loosening caused by wear or slight deformation. |
| 4 | Bracket shows signs of severe and permanent deformation; extinguisher is secure. |
| 0 | Bracket fails due to breakage or wear; extinguisher is lost. |

STATIC LOADING, BRACKETS, WEIGHTING INDEX: 10

| Score | |
|---|---|
| 10 | Maximum load achieved with bottle remaining securely in place. No deformation. |
| 7 | Maximum load achieved, bottle in place with temporary deformation caused by the existing stress. Deformation relaxed when stress is removed. |
| 4 | Maximum load achieved. Bottle in place with permanent deformation to bracket. |
| 0 | Bottle lost from bracket before or at maximum load. |

# APPENDIX C

# DRAFT PROCUREMENT DESCRIPTION



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WARNER ROBINS AIR LOGISTICS CENTER
DIRECTORATE, MATERIAL MANAGEMENT
ITEM MANAGEMENT DIVISION

PURCHASE DESCRIPTION
WR-ALC/IRA 4210-099
13 APRIL 1981

EXTINGUISHER, FIRE, BROMOCHLORODIFLUROMETHANE, AIRCRAFT, PORTABLE (HALON 1211)

1. SCOPE AND CLASSIFICATION

1.1 Scope. This purchase description covers aircraft type, rechargeable hand-portable fire extinguishers of the stored-pressure type charged with Bromochlorodifluoromethane (Halon 1211) and suitable aircraft type mounting brackets.

1.2 Classification.

1.2.1 Sizes. The extinguishers shall have at least the following UL ratings as defined in UL 711 and shall contain the required amount of Halon 1211. The weight shown is the minimum amount of Bromochlorodifluromethane to be furnished in the extinguisher.

| Size | UL Classification And Rating | Minimum Quantity Of Halon 1211 |
|---|---|---|
| 5 | 10B:C | 5 pounds |
| 17 | 2A:60B:C | 17 pounds |

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issues in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein:

Federal Specifications

| | |
|---|---|
| PPP-B-601 | Boxes, Wood, Cleated-Plywood |
| PPP-B-621 | Boxes, Wood, Nailed and Lock-Corner |
| PPP-B-636 | Box, Fiberboard |
| PPP-T-60 | Tape; Packaging, Waterproof |

Federal Standards

| | |
|---|---|
| Fed Std No 123 | Marking for Domestic Shipment (Civil Agencies) |
| Fed Std No 595 | Colors |

(Activities outside the Federal Government may obtain copies of Federal Specifications, Standards and Handbooks as outlined under General Information in the Index of Federal Specifications and Standards and at the prices indicated in the Index. The Index, which includes cumulative monthly supplements as issued, is for sale on a subscription basis by the Superintendent of Documents,

U.S. Government Printing Office, Washington, DC.

(Single copies of this specification and other Federal Specifications required by activities outside the Federal Government for bidding purposes are available without charge from Business Service Centers at the General Services Administration Regional Offices in Boston; New York; Washington, DC; Atlanta; Chicago; Kansas City, MO; Fort Worth; Denver; San Francisco; Los Angeles; and Seattle, WA.)

(Federal Government Activities may obtain copies of Federal Specifications, Standards, and Handbooks and the Index of Federal Specifications and Standards from established distribution points in their agencies.)

Military Standards

| | |
|---|---|
| MIL-STD-105 | Sampling Procedures and Tables for Inspection by Attributes |
| MIL-STD-129 | Marking for Shipment and Storage |
| MIL-STD-810C | Environmental Test Methods |

(Copies of Military Specifications and Standards required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other Publications. The following documents form a part of this specification to the extent specified herein. Unless a specific issue is identified, the issues in effect on date of invitation for bids or request for proposal shall apply.

Underwriter's Laboratories (UL), Inc., Standards:

| | |
|---|---|
| UL 299 | Dry Chemical Fire Extinguishers |
| UL 7.. | Classification, Rating, and Fire Testing of Classes A, B, and C Fire Extinguishers and for Class D Extinguishers or Agents for Use on Combustible Metals |
| UL 1093 | Halogenated Agent Fire Extinguishers |

(Application for copies should be addressed to the Underwriter's Laboratories, Inc., 1285 Walt Whitman Road, Mellville, Long Island, NY 11749; 207 East Ohio Street, Chicago, IL 60611; or 1655 Scott Boulevard, Santa Clara, CA 95050.)

National Fire Protection Association (NFPA) Standard:

| | |
|---|---|
| No. 10 | Standards for the Installation, Maintenance, and Use of Portable Fire Extinguishers |
| No. 12B | Halogenated Extinguishing Agent Systems Halon 1211 |

(Application for copies should be addressed to the National Fire Protection Association, 60 Batterymarch Street, Boston, MA 02110.)

National Motor Freight Traffic Association, Inc., Agent

National Motor Freight Classification

(Application for copies should be addressed to the American Trucking Associations, Inc., Tariff Order Section, 1616 P Street, NW, Washington DC 20036.)

Uniform Classification Committee, Agent

Uniform Freight Classification

(Application for copies should be addressed to the Uniform Classification Committee, Room 1106, 222 South Riverside Plaza, Chicago, IL 60686.)

(Technical Society and Technical Association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

## 3. REQUIREMENTS

3.1 Conformance to Underwriter's Laboratories, Inc. Requirements. All fire extinguishers furnished in accordance with this specification shall conform to the Underwriter's Laboratories requirements for Halon 1211 Fire Extinguishers. All contractors shall furnish proof showing this. The label will be accepted as evidence that the fire extinguisher conforms to this requirement. In lieu of the label, the contractor may submit independent proof, satisfactory to the contracting agency, that the fire extinguishers conform to the applicable UL requirements for Halon 1211 Fire Extinguishers.

3.1.1 Compliance with Requirement. A contractor's proposed Halon 1211 Fire Extinguisher shall comply with both the above requirements and the other requirements of this specification in order to be considered acceptable.

3.2 Production Model. The supplier shall furnish within the time period specified (see 6.2), one extinguisher of the size specified in the contract to prove, prior to starting production, that his production methods and choice of design will produce extinguishers that comply with the requirements of this specification. Examination and tests shall be those specified herein. Any changes or deviations from the preproduction model during production shall be subject to the approval of the contracting officer. Approval of the preproduction model by the contracting agency shall not relieve the supplier of his obligation to furnish extinguishers conforming to this specification.

3.3 Standard Product. Each extinguisher furnished under this specification shall be a currently standard Halon 1211 fire extinguisher produced by an established manufacturer, except for any deviations from the manufacturer's standard product that are required by this specification. 11 accessories and components normally furnished commercially with the standard product offered under this specification, shall be in the same quantity and of the same quality as furnished commercially with the standard product.

3.4 Design and Construction. The fire extinguisher shall be designed and constructed to permit easy operation, inspection, recharging and maintenance, and shall conform to all applicable requirements specified in UL 299, UL 711 and any other UL documents pertaining to Halon 1211 fire extinguishers. The fire extinguisher shall be designed to withstand 25 complete discharges and 25 recharges without affecting performance or loss of pressure. When UL allows for an optional design feature, material, or construction, the choice shall be made by the manufacturer provided it conforms to all other UL requirements and this specification. The extinguisher shall be fitted with safety devices or covering for all parts that present safety hazards. The devices shall include pressure gauges, metal locking pin and seal. The extinguisher triggering mechanisms shall be designed in such a manner that they may be operated by personnel wearing heavy work or flight gloves or artic mittens. The extinguisher shall be built to withstand the strains, jars, vibrations and other conditions incident to shipping, storage, installation and service in the aircraft environment.

3.4.1 Parts. Aluminum parts shall be treated with a chromate chemical conversion process or anodized to further inhibit effects of corrosion. Exposed working parts (such as, valves, springs, and pins) in the discharge or actuating assemblies shall be made of suitable nonferrous metal, austenitic stainless steel, or suitable plastics which can withstand frequent exposure to Halon 1211 without damage.

3.4.2 Exterior Surfaces. All metal exterior surfaces of extinguisher shells and mounting brackets shall be treated or coated to resist normal atmospheric corrosion and shall be capable of passing the 200-hour salt spray test as described in 3.5.4. Unless otherwise specified (see 6.2), shells shall be painted a lime yellow color. This color will identify these items as suitable for aircraft installation, and readily distinguish them from red colored ground units.

3.4.3 Shape. The extinguisher, exclusive of valve, handle and pressure gauge, shall be cylindrical in shape with the bottom of the cylinder skirt flat.

3.4.4 Discharge Nozzle. The discharge nozzle shall be a part either of the discharge valve or operating head or it can be attached to the discharge valve or operating head with a flexible hose. Extinguishers UL rated 10B:C shall be of the fixed nozzle type. Fixed nozzle shall be attached to the operating head/discharge valve and be easily removable by unscrewing from the operating head for maintenance. Extinguishers having UL classifications of 1A:10B:C and 2A:60B:C shall have the nozzle attached by flexible hose.

3.4.5 Agent Release Mechanism. The agent release mechanism shall be of the squeeze lever type, and contain the actuating mechanism which will break the extinguishers charge seal. The mechanism shall contain suitable seals to permit control of the discharge. Extinguishers UL rated 1A:10B:C and 2A:60B:C shall be configured whereby the centerline of the carrying handle (which incorporates the squeeze lever mechanism) is on the same longitudinal axis as the extinguisher charge, thus permitting the extinguisher to be carried and operated in an upright (vertical) position.

3.5 Durability. The extinguisher shall perform as required after exposure to the following flighworthiness/crashworthiness tests when mounted in bracket to be furnished.

3.5.1 High Temperature. According to Method 501.1, Procedure II, MIL-STD-810C.

3.5.2 Temperature Altitude. Modified from Method 504 1, Procedure I, MIL-STD-810C. Must survive temperatures of -60°F to +150°F at altitudes (low pressure) of 50,000 feet.

3.5.3 Temperature Shock. Must withstand rapid temperature changes of +80°F to -60°F and -60°F to +95°F.

3.5.4 Corrosion (Salt Spray). According to Method 509, MIL-STD-810C, for a duration of 200 hours instead of the specified 48 hours.

3.5.5 Acceleration. According to Procedure I (structural) and Procedure II (operational) of Method 513.2, MIL-STD-810C.

3.5.6 Vibration. Modified from Method 514.2, MIL-STD-810C. Extinguishers must survive vibrations of 11 cps at an amplitude of 0.95 inch (5.8g) for a duration of 30 minutes.

3.5.7 Ballistic Penetration. The charged extinguisher shall be capable of withstanding the impact of 0.50 caliber M-2 armor piercing projectile without shattering or fragmentation of the body.

3.6 Classification and Rating. The extinguishers shall be capable of successfully extinguishing UL 711 test fires and shall have the following minimum UL classifications and ratings:

| Extinguisher Size | UL Classification and Rating |
|---|---|
| 5 | 10B:C |
| 17 | 2A:60B:C |

3.7 Pressure Gauge. The extinguisher snall incorporate a pressure gauge marked to identify the proper operational pressure and graduated in increments no greater than 25 psi. Operating pressure at 70°F (±5°F) shall be indicated by a green strip.

3.8 Burst Pressure. The extinguisher's cylinder shall be capable of withstanding a minimum burst pressure of 600 psi.

3.9 Maximum Operating Pressure. Maximum operating pressure shall not exceed 195 psi at 70°F. A chart shall be furnished showing normal operating pressures at various operating temperatures.

3.10 Leakage. The extinguisher leakage rate shall be in accordance with the applicable requirements specified in UL 1093.

3.11 Mounting Bracket. Unless otherwise specified (6.2), a suitable aircraft type mounting bracket shall be furnished with each extinguisher. Otherwise, the extinguisher shall be furnished without a mounting bracket.

3.12 Mounting Bracket Durability. The mounting bracket must perform as required during and after exposure to the following flightworthiness/crashworthiness tests.

3.12.1 Corrosion (Salt Spray). See 3.5.4.

3.12.2 Acceleration. According to Procedure I (structural) of Method 513.2, MIL-STD-810C.

3.12.3 Vibration. (See 3.5.6). Loaded brackets must withstand these vibratory stresses for a minimum of six hours continuous vibration of 11 cps at an amplitude of 0.95 inch (5.8g).

3.12.4 Static Loading. Must withstand static loads of 200 pounds downward and 88 pounds upward along the axis of the extinguisher mounted vertically, and 200 pounds force outward (90 degrees to longitudinal axis) at a point midway between the strap and the bottom of the bracket.

3.13 Pressurizing Instructions. The fire extinguisher shall be supplied, charged, and pressurized with nitrogen to the required operating pressure.

3.14 Markings. The following marking and instructions shall be shown on each fire extinguisher.

3.14.1 The markings specified in UL requirements for Halon 1211 Fire Extinguishers.

3.14.2 Fire extinguisher operational instructions, including a picture clearly depicting the method of operation.

3.14.3 Detailed recharging instructions.

3.14.4 Warning concerning exposure and operating distances.

3.14.5 Additional information shall include: clear identification of contents, full and empty weights of complete extinguisher, manufacturer, manufacturer's serial number, and contract number.

3.14.6 The data plate shall be composed of material similar to that of the body of the extinguisher. The plate shall be permanently and legibly printed or stamped and securely attached to the extinguisher in a conspicuous location.

3.15 Recharging. Recharging shall be accomplished without the use of special tools and shall be able to be accomplished at either base level and/or by the manufacturer's local service representative.

3.16 Workmanship. The extinguisher shall be constructed, assembled, and finished in a manner to assure good quality equipment of an overall neat appearance.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.2 Classification of Inspection.

a. Preproduction inspection (see 4.3).
b. Acceptance inspection (see 4.6).
c. Inspection of preparation for delivery (see 4.9).

4.3 Preproduction Inspection. A sample of two articles from each lot for size of extinguisher shall be examined and tested as specified in 4.7 and 4.8. Presence of one or more defects shall be cause for rejection.

4.4 Lot. A lot for inspection purposes shall consist of all fire extinguishers of the same size submitted for inspection at the same time and place.

4.5 Sampling. Sampling for acceptance inspection shall be in accordance with inspection level S-2 of MIL-STD-105 with an Acceptable Quality Level (AQL) of 4.0 percent.

4.6 Acceptance Inspection. Each extinguisher shall be examined as specified in 4.7. Presence of one or more defects shall be cause for rejection.

4.7 Examination. The extinguisher shall be examined for the following and similar defects:

a. Missing UL label or lack of other evidence of conformance to UL requirements (see 3.1).
b. Materials not as specified (see 3.4).
c. Safety locking devices and seals not as specified (see 3.4).
d. Non-conformance to UL requirements.
e. Marking, operational, recharging or maintenance instruction not as specified.
f. Damaged components or evidence that the extinguisher is inoperable.
g. Workmanship not as specified (see 3.16).

4.8 Tests. Two fire extinguishers shall be tested at the Air Force Engineering and Services Center, Tyndall AFB, FL, as follows:

4.8.1 The UL label or other proof (see 3.1) shall be accepted as evidence that the extinguisher has passed all the testing required by UL for Halon extinguishers and by UL 711. In lieu of the label or other proof, the contractor will be required to conduct all testing required by UL for Halon extinguishers and by UL 711.

4.8.2 Demonstrate capability of being operated 25 times and recharged (see 3.4).

4.8.3 Demonstrate recharging procedure to verify recharging instructions are correct (see 3.14).

4.8.4 Disassemble extinguisher to verify simplicity of performing maintenance when required.

4.8.5 Demonstrate extinguisher's flightworthiness/crashworthiness capability (see 3.5).

4.8.6 Demonstrate securing extinguisher in mounting bracket and adequacy of mounting bracket (see 3.12).

4.9 Preparation for Delivery Inspection.

4.9.1 Inspection of Preparation for Delivery Requirements. An inspection shall be made to determine that the preservation, packaging, packing, and marking comply with the requirements in section 5. Defects shall be scored in accordance with Table I. For examination of interior packaging, the sample unit shall be one shipping container fully prepared for delivery, selected at random just prior to the closing operations. Sampling shall be in accordance with MIL-STD-105. Defects of closure listed shall be examined on shipping containers fully prepared for delivery. The lot size shall be the number of shipping containers in the end item inspection lot. The inspection level shall be S-2 with an AQL of 4.0 defects.

TABLE I

CLASSIFICATION OF PREPARATION FOR DELIVERY DEFECTS

| EXAMINE | DEFECTS |
|---|---|
| Markings (exterior & interior) | Omitted, incorrect, illegible, improper size, location sequence, or method of application. |
| Materials | Any component missing or damaged. |
| Workmanship | Inadequate application of components, such as incomplete closure of container flaps, loose strapping, inadequate stapling. Distortion of container. |

5. PREPARATION FOR DELIVERY

5.1 Packaging. Packaging shall be level A, B, or C, as specified (see 6.2).

5.1.1 Level A. Each complete extinguisher shall be packaged in a box conforming to PPP-B-636, class weather resistant, V3C, style optional. The boxes shall be closed in accordance with the appendix to the box specification and in addition shall have all seams, corners, and manufacturer's joints taped with minimum 3-inch wide tape conforming to PPP-T-60, Type III, Class I, color optional. The tape shall extend over corners and edges of the box.

5.1.2 Level B. Each complete extinguisher shall be packaged in a close fitting fiberboard box conforming to PPP-B-636, class domestic, style optional.

5.1.3 Level C. The extinguishers shall be packaged to afford adequate protection against damage during shipment from the supplier to the initial destination. The supplier's standard package may be used provided it conforms to these requirements.

5.2 Packing. Packing shall be level A, B, or C, as specified (see 6.2).

5.2.1 Level A. Complete extinguishers, packaged as specified in 5.1, shall be packed in close fitting boxes conforming to PPP-B-621, Class 2, style optional; or to PPP-B-601, overseas type, style optional, Grade B. Boxes shall be strapped in accordance with the appendix to the applicable box specification. The gross weight of boxes shall not exceed 200 pounds.

5.2.2 Level B. The number of packaged extinguishers specified (see 6.2) shall be packed in a close fitting fiberboard box conforming to PPP-B-636, type CF or SF, Class domestic, style RSC. Each box shall be strapped.

5.2.3 Level C. The fire extinguishers shall be packed in a manner which will insure arrival at destination in satisfactory condition and be acceptable to the carrier at lowest rates. Containers and packing shall comply with Uniform Freight Classification or National Motor Freight Classification.

5.3 Marking.

5.3.1 Civil and Military Agencies. In addition to any special marking required by the contract or order (see 6.2), interior package and exterior shipping containers shall be marked in accordance with FED Std No. 123 or MIL-STD-129, as applicable.

6. NOTES

6.1 Intended Use. These extinguishers are intended for use on board aircraft where a clean, non-corrosive agent is needed to prevent contamination and residue. Size 5 extinguishers are intended for Class B and C fires; size 17 is intended for Class A, B, and C fires.

6.2 Ordering Data. Purchasers should select the preferred options permitted herein and include the following information in procurement documents:

a. Title, number, and date of this specification.
b. Size required (see 1.2.1).
c. Time period for submitting preproduction model (see 3.2).
d. Color desired, if other than specified (see 3.4.2).
e. Specify when no mounting bracket or a vehicle mounting bracket is required (see 3.6).
f. Level of packaging required (see 5.1).
g. Level of packing required (see 5.2).
h. Quantity of extinguishers in the shipping container (see 5.2.2).
i. Marking desired, if other than specified (see 5.3.1).



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